THE MARCH
SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL

THE SCIENCE PRESS

LANCASTER, PA.—GRAND CENTRAL TERMINAL, N. Y. CITY—GARRISON, N. Y.

Yearly Subscription $5.00 Single Copies 50 cents

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THE SCIENTIFIC MONTHLY

MARCH, 1932

WHY WAVE MECHANICS?

By Professor F. M. DENTON

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Prologue

Why physics? If man's object is happiness, he must justify his invention of physical science by showing that it has promoted happiness. Aristotle's ideas of physics (385 to 322 B. C.) were primitive. Was life a less happy adventure for him than it is for us?

Physical science has improved man's methods of travel, of lighting, of heating, of communication, yet with every improvement have come new duties and new forms of unhappy routine.

And how small have been the improvements! The speed given to locomotion has but shortened the hours spent in reflection and drawn out those given over to dull routine. One of the delights of the few rich men who love culture is to travel by coach behind horses.

Means of lighting and heating have been improved, yet the ideal drawing-room of to-day is lighted by candles and heated by flaming logs.

Electricity has brought miraculous means of communication, yet the woman of culture writes with a quill on hand-made paper.

Life is but little longer; health is but little better; sanity has not grown nor the love of beauty.

The love of thought is no greater. The great man is no more capable of thought nor the average man less incapable to-day than thousands of years ago.

Physics is practically useful, its social object being the prediction of future events in the physical world. The sciences of physics and of history combine in performing for society the function which memory performs for the individual; they give of the past a record so orderly that its intelligent inspection discloses the future.

Science has developed the craft of living but has done little to promote the art of life. Always the art of life belongs to the individual rather than to the group.

The pursuit of happiness is often vain, but of this man may be sure, that the well-ordered exercise of his faculties brings happiness. A high faculty is thought, and it is thrice blessed—it blesses highly him who uses it in logic, in reflection, or (mostly highly) in creation.

Physical science offers unlimited scope for the exercise of thought in those three blessed ways, but it is only the rare and gifted man who loves their exercise. It is by holding out this reward of happiness to her followers that science has drawn the world's most thought-gifted men after her and has so wonderfully thriven.

With all its efforts to sugar-coat the pill of learning, education has neglected the attractions there are in thought. Those attractions appear in a study of works of thought in their original forms. Euclid is an exercise in logical thought

far more stimulating than any modern introduction to geometry. The modern books may be less faulty in method, but they are dry bones.

Mechanics is made fascinating by Galileo in his book "Two Discourses," to which reference will be made later. Written as it is in the form of a wordy warfare it arouses the fighting spirit in a student and puts a vigor into his logical thinking which the ordinary blase text fails to excite even in the most contentious mind.

Creative thought is neglected in education still more seriously. It is the element of creation in it which gives attraction to invention. The child who loves toys becomes the man who loves invention. The word "toy" has the same root as "zeug" in the German words "Werkzeug," a tool, and "erzeugen," to create.

Every man takes childlike delight in the device or the idea which he feels is his own creation. The pleasure of using such a thing outweighs a hundred inconveniences in its use. A typical example is that of the unknown inventor whose original idea is conveyed in the lines "I eat my peas with honey, I've done so all my life, it makes the peas taste funny, but it keeps them on the knife." The joy of indulging the child of his own thought outweighed indigestion and breach of etiquette. The method used by this inventor was closely related to Millikan's method of holding electrons on oil drops—an invention justly reckoned a stroke of genius.

The joys of reflective thought come to the poet and the philosopher and there is, to-day, no good scientist who is not a philosopher. Students wade through the finished creations of the poets, only the gifted few keeping awake. All would keep awake if they could be shown the daily lives of the poets as they wrote; could see the ragged shirt-cuffs bearing original versions, and could hear from the poet himself all the struggles by which the later versions were evolved.

Thus it is because of the art there is in science that science is good. The essence of art is creation. The tools of the thought-artist are words and symbols. It is because he is an artist that the good man of science cares rather for the ideas behind phenomena than for phenomena.

Training and education are powerless to produce either men of art or men of science, and there is as little hope that, some day, all men will understand Einstein as that all men will understand Bach.

And if, as seems likely, the theory of relativity will remain forever mysterious to the majority of men, much more will those theories remain mysterious which are growing out of relativity. The youngest of these are the unified field theory and wave mechanics. So peculiarly difficult are these theories that the task has become a very interesting one of enquiring what they are and why they have been invented.

Monologue

This paper is intended as a discussion of scientific method, based on a brief review of the outstanding theories of physical science since the time of Newton (1642–1727). The first of these theories is Newtonian mechanics. In order to bring electrical phenomena into the scheme of Newtonian mechanics, Clerk Maxwell (1831 to 1879) invented the electromagnetic theory, by which light became an electromagnetic phenomenon. The velocity of light is a quantity of fundamental importance in every branch of physics. In Clerk Maxwell's theory it is constant; in Newton's it ought to be variable. The difficulty was winked at until 1905, when Einstein invented his theory of relativity. That theory reconciled the behavior of light with that of moving things in gen-

eral, but it found no place for other electrical phenomena.

Einstein's unified field theory is an endeavor to bring all phenomena, whether electrical or mechanical, into the generalized theory of relativity.

During the growth of relativity (1905 to 1915) a new complication was coming into experimental physics and, again, light was the culprit. It was behaving in a large class of phenomena rather like bullets than like waves. Matters were but poorly patched up by Planck's Quantum Theory (1900).

Physicists began to follow two lines of theory involving notions about light and radiation which were mutually contradictory. Out of the struggle have come the group of theories known as wave mechanics, in which the distinction between bullets and waves is held to be unwarranted and misleading. The pioneers in wave mechanics are Heisinger, de Broglie and Schroedinger.

In order to make the meanings and relations of the theories of physical science intelligible, it is necessary to describe them in one continuous line of thought. Intelligent reasoning demands continuity. We reason by thoughts and thoughts grow out of memory. Reasoning is without meaning if its "thread" is lost. A long break in memory is called amnesia, and amnesia is a form of insanity.

Complete knowledge would provide a continuous picture of the consequences of a given set of conditions. Consequences must be consecutive; events must form a sequence, and a sequence must be definite and unambiguous. A break in a line of reasoning is a point at which doubt creeps in.

The dogmas just recited form part of the practical creed of most men, and confusion is unavoidable unless they are respected.

Aristotle's knowledge of physics was so limited, so full of breaks, that it was impossible for him to form a clear picture of any complex sequence of physical events without the help of fancy. If, for instance, he had tried to picture a big and a little man throwing themselves simultaneously from the top of a tower, he would either have been in doubt as to which man would strike earth first, or, if he had relied on his own peculiar notions, he would have concluded that the big man would reach earth so much earlier than the little one that the latter might use his big brother as a cushion to fall on. Galileo (1564 to 1642) discusses such problems with clear insight in his "*Discorsi e dimostrazioni matematiche intorno a due nuoue scienze attenenti alla mecanica e i movimenti locali,*" printed at Leyden in 1638, an English translation of which was published by Macmillan in 1914. He makes clear, without special experiment, the error of Aristotle's notion who held that "an iron ball of one hundred pounds falling from a height of one hundred cubits reaches the ground before a one pound ball has fallen a single cubit." Aristotle was an artist as well as a philosopher. Neither art nor science can suffer discontinuities. When blanks are found they must be filled—in art by fancy, in science by creation. Aristotle used fancy.

The theories created by Newton and Galileo removed doubts from men's picture of falling bodies. Nevertheless Newton's knowledge of physics was so limited that he was unable to form a clear picture of a complex sequence of events in the field of optics. He was in doubt as to the speed with which the light from the rising sun traversed the earth, and if he called light's speed with reference to the sun V miles per second, while the circumferential speed of earth was v, Newton simply did not know whether the speed of the sun's ray across earth was V or $(V+v)$ or $(V-v)$. His picture of light's behavior either had to have blank spaces in it or had to be filled by guesswork.

Einstein's theory has removed the guesswork from the problem of the speed of light and has improved the logical sequence of the sciences of mechanics and optics, but it has left science faced with new forms of discontinuity. Is a beam of light a wave in a continuum, or is it a hail of bullets?

The fight with this problem has brought new difficulties as well as new knowledge. Light has undoubtedly the property of bullets as well as that of waves. In trying to remove the absurdity from such a contradictory mixture of properties scientists have discovered a contradiction still more absurd. Bullets—the electrons we have always pictured clean and round like billiard balls—are waves. Nothing could be more absurd, yet nothing is more certainly a "fact." Davisson, Germer and others (1923 to 1927) have shown that just as a narrow beam of light may show diffraction bands of light and dark on a screen—the light energy crowding along certain preferred directions—so also will a narrow beam of electrons, after reflection from a metal surface, crowd along certain preferred directions.

The mind has no sort of picture to fit such queer events, and the picture which science offers to-day of the world of nature is full of blank spaces. How to fill those spaces by guesswork has been shown, very plausibly, by Heisenberg. How to fill them by "material waves" is suggested by de Broglie and by Schroedinger. The weakness in the method of "material waves" is that it leaves discontinuities in the relations between electrons. There is no visible way out. So great is the difficulty that scientists are to-day testing themselves to see whether while still remaining comparatively sane, they can accept the notion that reality involves discontinuity.

The difficulty of accepting discontinuity is seen by reading thoughtfully one of its fundamental consequences, namely, the notorious "Principle of Indeterminacy," which runs, "An electron can not have, simultaneously, both position and velocity." The absurdity of this is so great that words can hardly convey it. If we know anything at all about electrons we know they are usually in motion. Thus we know they exist in time. According to the new principle they can not also exist in space. Zeno would have enjoyed the situation; and, after all, it may be doubted whether we have in the world to-day any thinker greater than Zeno.

In the hope of making the development of modern science intelligible, it is useful to consider from a practical, unimaginative point of view some of the phenomena which have seemed to demand the theories.

The poets' notion that the starry heavens were a crystal bowl studded with bright jewels took no account of the fact that the sun was earth's powerhouse and the moon the engine of the tides. These facts and the observations of the astronomers demanded Newton's law of gravitation. The line of reasoning was simple. The simplicity and regularity of their relative motion led to the tentative assumption that sun and earth were interacting mutually, according to some physical law. There appeared to be some force between them. Symmetry and common-sense demanded that this force should depend only on the amount of matter in the bodies and their distance apart. Something analogous to elastic strings—"lines of force"—was demanded, joining earth to sun. Simplicity would be served if one common law could be found which might be obeyed both by bodies on earth and by stars. Every-day experience of the fact that the weight of a body was unaffected by the intervention of other bodies between it and earth demanded that the lines of force should be continuous

strings, not capable of being broken or cut. Symmetry demanded that the lines of force sent out by the sun should be straight radial lines whose density must fall off with the square of the distance from the sun's center. Hence came the inverse square law of gravitation. Such a law would account, mathematically, for the relative motions of sun and planets as well as of falling bodies on earth, provided it were assumed that, in the absence of such forces, those bodies (stars and stones) would move in what an earth-dweller called straight lines. The fact that the paths an earth-dweller would call "straight" would not be called straight by a Martian or a sun-dweller was not seen as an objection because people had not yet appreciated the "other fellow" condition in the scientific definition of "truth." Strictly, Newton's laws of motion are not laws of nature. They are mathematical deductions from the assumption that, in the absence of "forces," bodies would move in "straight" lines—an assumption which is scientifically meaningless, because "straight" is unavoidably ambiguous.

The attribution of the uniformly accelerated motion of falling bodies to the "force" of gravity combined with the common-sense demand that the "amount of matter" in a given body should be conserved led to Newton's definition of "force" by the equation $F = MA$.

The Newtonian law of relative velocity needed no experiment, but was "of necessity" true, if the Newtonian-Euclidean picture of the world was true. A man walking forward at 5 miles per hour along the deck of a ship travelling 10 miles per hour was, "of necessity" moving, relatively to earth, at 15 miles per hour. The reasoning was applicable to anything whatever, conveyed by any vehicle whatever. For instance, it should be applicable to a ray of light travelling on a stream of water through a pipe. Fizeau (in 1856) found that in this case Newton's law was wrong. The arithmetic sum of the velocity of light in water and the velocity of the water in its pipe proved actually to be greater than the velocity of the light carried by the water along the pipe. This "absurd" behavior of light was found to be in accord with the "dragging coefficient" which was invented in 1816 by Fresnel to account for some of the facts of aberration. That coefficient is closely related to the "Lorentz Transformation" of Einstein's relativity.

Light's behavior was excused but not explained by Fresnel's dragging coefficient, that coefficient being a brilliant guess, not a scientific deduction. For many years light's unorthodox behavior was winked at and in 1887 the Michelson-Morley experiment proved that the culprit was unrepentant. In 1905 Einstein proposed that since light was more powerful than science it might be well for science to capitulate, annulling its "classical" laws and inventing new ones to fit the "absurd" behavior of light. Einstein's success was a wonderful triumph for the scientific method. Instead of having to annul the old laws Einstein found that it was necessary only to complete them. For instance Einstein's law of relative velocity is $V = (v_1 - v_2)/(1 - v_1 v_2/c^2)$ where c is the velocity of light. For the special cases (and these happen to be all ordinary cases) in which the velocities are small compared with light's velocity Einstein's law is indistinguishable from Newton's.

Newton's assumption that the mass of a body is conserved remains true for bodies at rest or moving with any ordinary velocity, but the strict law, as formulated by Einstein, is $M = M_0/\sqrt{(1 - v^2/c^2)}$ in which M_0 is the ordinary Newtonian value of the mass and v is the body's velocity relatively to the observer.

Light and all known forms of radiation, as well as bullets, falling bodies,

planets and stars—all things obey these laws of Einstein better than they obey the laws of Newton.

By Einstein's theory the law of inverse squares for gravitation is not quite right. The exponent should not be 2, it should be 2.00000016. In a Newtonian-Euclidean world this not only is wrong, it is absurd. The geometry of Euclidean space demands the exponent 2. The density of the lines of force of a symmetrical radial field of gravitation must fall off as the square of the distance. Einstein has shown that the geometry of the physical world is non-Euclidean.

The big-scale events which have corroborated Einstein are well known, as, for instance, the bending of light in the sun's gravitational field. Among the small-scale but accurately observable events are the change of a body's mass with its velocity and the transformation of mass into energy. The transformation of mass into energy is thought to be demonstrated by the fact that the atomic weight of helium is exactly four, whereas its structure demands a weight of 4.032. The deficiency is explained as due to the energy given off during the formation of the gas from electrons and protons.

The fact that energy possesses mass is demonstrated by the well-known phenomenon of the "pressure of light." Anything which resists change in its motion has inertia, and inertia is mass. When light falls upon an opaque body it is stopped or deflected. Does it push against the body? If so it has mass. Lebedew showed in 1901 that light does push upon a mirror. In order that it might be moved appreciably by a minute blow the mass of the mirror had to be small; in order that the force of the blow might be as great as possible the mirror's surface ought to be large. For a given shape of mirror the ratio of surface to volume is a maximum for the smallest possible mirror. Lebedew used mirrors a fifth of an inch in diameter, suspended in a vacuum. He found that ordinary sunlight exerts a pressure of about a milligram on every square meter of an opaque surface. In proper accord with the notion that light has mass this pressure was found equal to the energy-density of the light.

The many corroborations of Einstein's theory which modern advances in physics have brought give great encouragement to the notion that the physical world is a world of continuity. This can not, however, reduce the seriousness of the ruffling which Planck's quantum theory has brought into the space-time continuum. Some of the facts demanding Planck's theory are simple, as, for instance, the photoelectric effect.

When light strikes the surface of a metal that surface emits negative electrons. This is true especially of the alkali metals, such as sodium. But the removal of these electrons requires energy. The energy required may be measured by finding the voltage to which the metal must be charged to produce a leakage of current. Einstein and others have found precise values for the number of ergs required to remove one electron from a given metal with a given velocity.

Common-sense would suppose, therefore, that the action of light would cause the emission of electrons only if its intensity were great enough. The ergs of light energy per square centimeter of the metallic surface ought to equal the energy of the emitted electrons (allowance having been made for what may be called the "surface tension" of the metal).

Experiment shows that no such intensity is required. The energy with which an electron leaves the light-excited surface depends on the frequency and not at all upon the intensity of the light. It is as though the electrons had the intelligence of schoolboys who, when the clock strikes eight, go forth with low energy, but when it

strikes twelve, shoot forth with high energy. This odd analogy may be carried a step further. The intensity of the light, of whatever frequency, determines the number of electrons leaving the plate per second; similarly, the loudness of the bell, whether it strike eight or twelve, determines how many boys will awake and go forth. Unfortunately, the rules of the game of science forbid the assignment of intelligence to electrons, and it is necessary to seek an explanation more prosaic.

The favored explanation is the quantum theory, according to which the old idea that the radiation from a point source is propagated after the manner of a rubber balloon expanding outwards from its center, its radius growing with the speed of light, must be replaced by some such picture as that of an expanding spherical cloud of bees. The wave-front is not like a uniform spherical shell of rubber, but is rather like currants peppered over the surface of a spherical pudding, each currant containing enough energy to eject one electron from the surface of a metal target. This crude picture must next be complicated by the notion that what each bee or currant carries is a quantum not of energy but of "action"—action being the product of energy and time. This makes the picture satisfy the condition that the energy of emission of each electron shall be proportional to the frequency of the radiation represented by the cloud of light quanta. The unit of "action" carried by each quantum—of whatever frequency—is Planck's constant, "h," which equals 6.55×10^{-27} erg-seconds. The product of action and frequency (that is to say erg-seconds and a number per second) is energy. A quantum of radiation of frequency ν carries energy $h\nu$, and it is this amount of energy that an electron possesses when it is emitted from a surface.

Such a picture of radiation as discontinuous has fatal objections; for instance, at a great distance from the source of the radiation the bullets (bees, currants or quanta) are scattered so sparsely over the wave front that the chances of any given spot on the target ever being hit are small. Hence the emission of electrons from the target should be patchy, and it should happen sometimes that considerable time would elapse between the arrival of the geometrical spherical surface, usually called the wave-front, and the ejection of an electron from a given spot on the target. The ejection is in fact practically simultaneous, at all points on the target, with the arrival of the geometrical wave-front.

The quantum idea is plausible, but it provides the mind with no logical picture. The very idea of discontinuity is unreasonable (or beyond reason) because the tool reason must use is memory, and memory with breaks can produce nothing better than a broken line of reasoning patched with guesswork.

The simple atomic picture used by the chemist is atomic only in a superficial sense; the "reality" of the chemical atoms lies in their chemical affinities, and we picture these affinities as the evidence of fields of force—for it is only through their fields that the atoms of different elements can be recognized and distinguished. A field of force has no fine-drawn boundaries; the gravitational field, for instance, of a particle extending through unbounded space. Similarly, the electron, though pictured crudely as a little billiard ball, has to be dealt with scientifically as a radial electric field extending throughout all space.

There is no more objection to the idea of discontinuous quanta than to that of atoms and electrons, but there is as much objection.

Wave mechanics tries to treat quanta as electrons have been treated, namely, to bring them into a field theory. The point of view from which the problem is being attacked is that of atomic struc-

ture. Bohr's (1913) notion of an atom as a planetary system provided the mind with a clear picture, but that picture involved mysterious discontinuities. Around the atom's center moved electrons in definite orbits. It was the dogmatic definiteness of those permitted orbits that reason could not suffer. What happened in the empty space between the orbits? Radiation was given out from an atom by the apparently miraculous jumps which electrons sometimes made from one permitted orbit to another. Where was the electron during the jump and what was happening to it? There was no intelligible answer. The principle of indeterminancy says it was "nowhere."

Bohr's planetary picture is wrong. What made it plausible? No microscope can look into an atom. This is stated dogmatically because, by sound principles of optics, in order that two points may be recognizable under a lens as distinct their distance apart must be at least λ/a centimeters; λ being the wave-length in centimeters of the light being used, and a the angle in radians subtended by the lens at either of the two points. This means, for instance, that if ordinary light were used, for which λ is about 6×10^{-5} cms, and we could put the object close to the lens, making a about 3; the size of an atom whose diameter might be clearly visible must exceed $(6 \times 10^{-5}/3) = 2 \times 10^{-5}$ cms. The probable diameter of an atom of helium is 2×10^{-8} cms—a distance one thousand times too small to be distinguished microscopically. As to the electron, it is supposed to have a diameter one fifty-thousandth of that of an atom.

The planetary atom of Bohr is an inference from many big-scale measurements; especially from spectroscopic data.

A gas which is heated, or through which an electron discharge passes, becomes excited, the motion of the electrons within the atoms becoming sufficiently vigorous to set up visible vibrations in the ether. (This seems to contradict the notion that matter moves through the ether without disturbing it. The ether idea is, however, at best an artificial makeshift, and we can suppose that although the ether offers no resistance to the motion of big things through it, it does resist the motion of electrons and take up energy from them). A narrow ribbon of such light forms a spectrum containing components of many colors, that is to say of many different frequencies. The simplest notion is that if the strip of light, after dispersion by a prism, forms, say, three separate images of different colors, there must be three electrons rotating at different speeds, and therefore in orbits of different radii, around the nuclei of the atoms.

The reasonableness of such a notion is tested by spectroscopic observations supplemented by alpha particle experiments, such as those of Geiger and Royds, from which the amount of positive charge on the nuclei can be inferred—and hence the number of electrons since the atom complete is neutral—and by experiments in which the atoms forming a gas are subjected to electronic bombardment.

The results of experiments such as have been outlined have led to many ingenious pictures of atomic structure, each of which is plausible, but all of which fail in important ways to fit experimental fact. The chief discrepancy is between the values obtained spectroscopically—especially by aid of the x-ray spectroscope of Moseley—for the numbers of the electrons within the atoms and their frequencies, and the values deduced from bombardment experiments. The frequency of the emitted light differs from the speed of rotation of any of the planetary electrons whose presence is disclosed by bombardment.

This difficulty, added to the impossibility of picturing the discontinuity introduced by the supposed orbit jumps, has called for some new mode of explanation and has produced wave mechanics.

Distinction must be drawn between the three forms of wave mechanics associated respectively with the names of Heisinger, de Broglie and Schroedinger. Heisinger, whose ideas are favored by Bohr, assumes that, however repugnant it may be to common sense, we must accept the fact of discontinuity. De Broglie and Schroedinger try to fill the world-continuum with waves. Except for this difference in intention, the three forms of the theory seem to be in fair agreement.

Discontinuity means ignorance or uncertainty. In the presence of uncertainty we have to make guesses, and in order to make good guesses we must use the mathematical theory of probability. Thus in Heisinger's theory Planck's constant "h" becomes a measure of "inaccuracy." This point of view may be explained in a common-sense way by reference to the problem of finding the position and the velocity of a given electron within an atom at a given instant. To do this by actual observation is impossible by means of any known microscope, but we will neglect the mere practical difficulties and suppose the very short-wave light of gamma rays (the wave-length of which is a hundred-thousandth of that of ordinary light) to be used in an imagined gamma-ray microscope.

As is well known the error in determining the position of a point by means of a microscope is λ/a, λ being the wave-length of the light in centimeters and a the number of radians subtended, at the object, by the lens aperture. Thus, for instance, if λ were one thousandth of a millimeter, the lens aperture were half a centimeter and the focal length two centimeters, the value of λ/a would be about one twenty-five-hundredth of a centimeter and the location of a point on the object (defined, say, as its distance from the center of the object) would have an uncertainty of (1/2,500) centimeter.

The electron's velocity may be found from its momentum, since the mass of the electron is known. The experiments of A. H. Compton (1923) on the scattering of x-rays by particles of graphite have shown that the ray of light thrown upon the electron while its position is being measured, must possess momentum equal to $h\nu/c$, h being 6.55×10^{-27} erg-second, ν the frequency of the light, and c light's velocity.

It is possible that the whole of this momentum may be added to that of the electron whose momentum is being measured, the error in momentum then being $h\nu/c$, which may be written h/λ since $\nu = c/\lambda$. How much of this momentum will be given actually to the electron depends on the direction of the light falling upon the electron, and all we know about that direction is that it lies within the aperture angle a. The probable error p_e in momentum is thus h/λ times a.

The probable error q_e in position was λ/a, and we have the interesting result, $p_e \times q_e = h$.

The quantity $p_e q_e$, the product of distance and momentum, is of the nature of "action"—since energy times time equals distance times momentum. The statement $p_e q_e = h$ thus means that in measurements of action—the most fundamental stuff in the physical world—there must always be a probable error of the magnitude h ($= 6.55 \times 10^{-27}$ erg-seconds).

Such an error is negligible in big events but becomes the "whole thing" in the ultra-microscopic events that go on inside an atom.

The notion of "action" is unfamiliar, but if we accept the conclusion of relativity that energy and matter are one,

then action may be thought of as matter times time, as, for instance, a brick times a second. There is nothing unfamiliar about that idea. A brick is an abstraction, for a brick needs time in which to have its being. A "brick-second" is a physical reality, it is a lump of "action."

The derivation which has just been given, of the equation $p_e q_e = h$, can not be taken to suggest that the error h might be avoided if a more perfect microscope were used, because λ and a cancel. The blame must be put upon h and not upon the method of measurement.

If the orthodox position be taken that nothing is real which can not conceivably be measured, then, since no method can be conceived by which the simultaneous position and velocity of an electron can be measured accurately, we must conclude that the notion that an electron can possess, simultaneously, both position and velocity, is wrong and probably meaningless. This is the position taken, officially, in Heisinger's theory, according to which science must be illustrated not by pictures but solely by mathematical equations.

De Broglie and Schroedinger seek to explain apparent discontinuities in terms of the interference of waves in continuous media. Any diffraction pattern with its bands of light and darkness may be called a discontinuous patch of light, but the conventional ether-wave explanation calls for nothing atomic or discontinuous. Thus effects apparently discontinuous may be consistent with a theory of continuity.

These continuity theories of wave mechanics are successful up to a point, but they reach then the same position and the same difficulty with which de Broglie's theory starts, namely, the necessity of assuming that the physical world is not picturable as a continuum. The inference is that there is an absolute characteristic in nature which shows itself as an "uncertainty."

Science thus becomes an application of statistical methods and the law of probabilities is seen as nature's fundamental law.

To conclude from this, however, that the physical world is a random shuffling of quanta of action is unwarranted and foolish. The fact that statistical methods give true predictions and useful results shows that the discontinuities are directed.

If I toss a penny it shows either head or tail, never a head and a half or a tail and a half. It is a matter of chance whether head or tail turns up. Nevertheless, in a hundred throws it is practically certain there will be fifty heads. In each throw there is the same amount of error, namely, one quantum of error. An error is something done without intention. It may be called "undetermined." From a hundred throws we deduce the thrower's intention, which was (if he had a sane orderly intention at all) to make the penny stand on its edge. Every step in the process is an error, yet the meaning of the process is definite.

Another familiar example is that of human handwriting. If the writing is, as usual, irregular and broken, then every little elemental stroke is inaccurate. If it be called on that account "undetermined," we may say, "although the elementary processes of the writing are in no way determined, yet the probabilities to be ascribed on statistical grounds to these individual processes may be treated as continuously variable and determined quantities." Such is the form of words used by some modern authorities in speaking of the processes of physical science. It may be questioned whether such words are warranted. Is it not misleading to say the individual processes may be "undetermined"?

In a game of chance—as, for instance, the tossing of a penny—the endeavor is to choose individual processes (the throws) which are "undetermined" as to their sign. This does not mean that the sign (head or tail) of each throw is uncaused; it means rather that the sign is determined by causes having no systematic relation to the game. We are accustomed to thinking that in such an actual case there must, strictly, be some distant relation between all the events, but that the relation of the forces deflecting the penny, to the throwing of the penny, is so distant as to be negligible. Yet surely, if we could do so we should make the sign of the throws obey causes absolutely unrelated to the game. Then the sign might be called "undetermined." But to use the word "undetermined" is misleading, because, though the sign of each throw is undetermined, there is something about each throw which is determined; and it is that something which comes to light in a long series of throws. Inspection of a long series discloses "indifference to sign." This is the characteristic of the game. Similarly in the handwriting. Inspection of a whole sentence—each element of which is inaccurate—disclosed definite meaning. The inaccuracy present in each stroke is undetermined, but in each stroke there is present something besides the inaccuracy.

If each stroke were characterized by nothing but inaccuracy then the statistical method (which, through practice, the eye always applies to handwriting and to pictures) could disclose no meaning in the writing. It is a general tendency present in each stroke which is the element of truth. Without that tendency the statistical method would disclose nothing. Statistical methods can disclose truth by canceling the errors which hide it, but they can not create truth. It is absurd to suppose that out of nothing but undetermined elementary processes determined results may grow. The elementary processes must have some determined characteristic giving them a relation, so that out of that relation the determined event may grow.

It is vain to attempt to abstract a physical conception from any of the wave mechanics theories in their present form. Perhaps no physical conception of nature's elementary processes is possible. A physical conception is a conception in terms of familiar notions. Both relativity and wave mechanics concern notions which are unfamiliar. Not until those notions have become familiar can a satisfactory physical conception be recognized for either theory. But to forego the enjoyment of a physical conception is much easier than to accept as final a theory of discontinuities. Such a thing is acceptable as a temporary makeshift but not as final.

The makeshift conception that Aristotle had to tolerate was that of a multitude of separate worlds, each with its own "god." Scientific events were not distinguished from spiritual events. There was no world of science; no language of science; no logic of science. It is striking that a thinker of Aristotle's power could be such a child in scientific reasoning as to favor the idea that a heavy body—because it is heavy—must fall more rapidly than a light one. In scientific thinking Galileo was far ahead of Aristotle. Here is the brief substance of Galileo's argument about falling bodies:[1]

Aristotle claims that a light bullet falls less rapidly than a heavy one. Suppose then that the heavy bullet be lying just on top of the light one as they fall. The light one must retard the heavy one, and the combined pair must move a little more slowly than the heavy one would if falling alone. But the combined pair, being a heavier thing

[1] See Galileo's "Dialogues Concerning Two New Sciences" already referred to, p. 64.

than the heavy bullet alone, ought to fall, according to Aristotle, faster. Such contradiction shows Aristotle's theory to be absurd.

Newton's world, in the improved form in which he left it, was hampered by the discontinuity separating time and space. In introductions to relativity that peculiarity of the Newtonian world is made clear. An observer sees the path along which he himself happens to be moving as a combination of space and time—every mile of travel involving some minutes of time. Only the path perpendicular to his own—the path along which his own motion has no component—is pure space; and this path, to a differently directed traveler, is a mixture of space and time. Relativity removed that discontinuity. The discontinuity which, in its turn, disturbs relativity is a very fundamental one; perhaps it is the very same which, in different guise, plagues wave mechanics.

A fundamental assumption made by Einstein in his "Special and General Theories" was this, that rods and clocks were true standards in the sense that if they were found in mutual agreement at the outset when all were together, at rest in one spot, then, in spite of contractions and slowing due to motion and to gravitational fields as they went on their various journeyings, they would be found still in agreement on coming together again for restful comparison.

The difficulty is brought out by the case of the "identical twins." It follows from the general theory of relativity that if there are two identical twins, A and B, one of whom, A, remains at home while B goes off at high speed for a journey, returning after many years, then, on reunion, A will be a gray-haired old man while B will have remained youthful.

This deduction from relativity is not easy to explain, but light may be thrown on the matter by some simple thoughts.

Relativity defines reality or truth as that which is seen similarly by all observers. If then an observer can be specified to whom the men A and B must always appear alike, the contention that A will have aged more than B will have been disproved.

Now if an observer X be specified who chooses to move in such a way that he is always midway between A and B, then, in reference to him (X) the velocities of A and B must be always equal. Hence the contractions seen in A and B and the slowings seen by X in their watches and their beards will be the same for A as for B. And when finally A, B and X are reunited, X will find A and B still "identical."

That argument is incomplete, for it neglects gravitation. A and B were born within earth's gravitational field in which clocks were slowed and rods shortened. As B moved away, possibly into regions of less gravitation, X would find it impossible to choose his own motion so that A and B would look always alike. To be midway between A and B would not suffice, for, in addition to maintaining his velocity relative to A the same as relative to B he would have to accelerate himself in one direction at two rates at once, in order to counteract the two different gravitational fields to which A and B were subjected. Do what he might X would see differences between A and B. Those differences would be "real."

When the "identical twins" are a pair of yardsticks, the conclusion is that those sticks must not be assumed to remain alike. They start out alike, but later, when brought together again, they will be unlike. This difficulty may be regarded as a case of discontinuity. To the observer who lives in the calibrating room to which rods return to be checked, it will appear that the length of a rod is a quantity varying in erratic jumps.

Weyl and Eddington have tried to surmount that difficulty by discarding

the idea that the world is capable of an unambiguous metrical description. Instead of equipping each observer with a standard yardstick they send him out with no stick at all, but tell him to use the yardstick he finds on the spot. It does not "really" matter what lengths those local sticks have. According to this theory the physical world is described in terms of relative position and not by quantitative measurement.

The fact that Planck's constant, h, has a definite size seems to suggest that, after all, a metrical description must be possible and in his unified field theory Einstein does make possible a metrical description of physical events. The practical interpretation of the theory has not yet been disclosed.

A complete theory must find room for every known phenomenon.

The phenomenon of cosmic rays is new and but little understood. Rays of light possess speed and momentum, and when they hit atoms they sometimes drive out electrons. These loose electrons are ready to be set in motion by electromotive force, hence the space in which they are produced becomes an electrical conductor.

X-rays and the still higher frequency gamma rays make ordinary air conductive; Hess discovered in 1912 that cosmic rays are still more effective. The frequency of the cosmic rays is probably of the order of 5×10^{22}, while that of gamma rays is 5×10^{19}, x-rays 3×10^{19} and of ordinary light 5×10^{14} cycles per second.

Recent work has been done by Millikan and Cameron which shows that cosmic rays have 700 times the penetrative power of x-rays, being able to pass through 30 feet of lead. Cosmic rays fall upon earth from no particular direction; it is thought that they come from interstellar space. Their apparent lack of systematic relation with any other phenomena fits them well for use in games of chance.

The game of penny-tossing is a game of true chance for two reasons; first, a penny is so small that the force required to knock it over when standing on edge is a much smaller force than can be detected and controlled, voluntarily, by a man's muscles. A penny as big as a dinner plate would not do, for, with practice it could be made to fall as desired. Secondly, penny tossing is a game of true chance because the forces determining the sign of the throw—such forces as accidental breezes, vibrations of the thrower's chair or disturbances of his nerves—have but very distant relation with the throwing process. It is because these conditions are satisfied that the game gives, practically always, the result which the mathematical theory of probability demands.

It is not easy to know whether a proposed game is one of true chance, but in cases in which the experimental results do actually agree with the theory of probability the inference is fair that the conditions necessary for chance are being fulfilled.

The results of experiments in atomic physics are predictable by no theories except those which use the mathematics of probabilities; hence the tentative inference is warranted that the conditions of true chance exist inside atoms. As applied to the planetary picture in which the observable effects (line spectra, etc.) are supposed to be due to an "undetermined" jumping of electrons from orbit to orbit, the suggestion seems plausible that the unrelated accidental causes of those erratic jumps are cosmic rays. It is good to have something to blame for one's failure. What could be more convenient for science than to put the blame for its failure to find a reasonable theory of atomic phenomena upon the shoulders of the infant cosmic ray?

EPILOGUE

In a final analysis, the idea of truth or falseness is inapplicable to an individual ultimate element. It is only the relations of such elements that possess significance and may be true or false. Here, for instance, is a sentence, every word of which is without meaning, "Cees tym bi thef orlok," but whose meaning every reader knows. The sentence has a continuity; the words have a relation. Without relation there is no significance; without continuity (actual or inferred) there is no relation.

This peculiar sentence seems to be a case in which the group has a meaning, although each element is without meaning. A more striking case of this sort is that of a message in the dots and dashes of the Morse code. A dot standing alone has no meaning, neither has a dash; but a group has meaning. Here, apparently, is a discontinuous series exhibiting a relation which has meaning. But is the series really discontinuous? If so why does · · · mean S while · · · means EI? This is because the relation involves the spacing as well as the dots, and the series is not really discontinuous. Discontinuity would demand that the spaces between elements should be truly empty—filled with nothing that has significance. Actually the spaces have as much significance as the dots, and the discontinuity is not real. And since an isolated dot has no meaning we ought to say that not the dots and dashes are the elements in the message but rather the elements are dot-plus-space groups. The continuity is then obvious.

Science defines the real as the unambiguously measurable, and since a space enters into the measure relations of the group just as a dot or a dash, it is just as real.

The case of the "forelock" sentence is interesting because it seems like a case in which real significance is conveyed without any measure relations at all, nothing metric being apparent in the relation conveying the significance. But is there really nothing metric in the sentence? Are not the time-spacing of the syllables and their intensity-relation essential to the significance? Without memory's recognition of the sentence no significance would be conveyed; and recognition is a sort of measurement.

The discussion of the problems of atomic science tends to become as confusing as the discussion of religion, if those arbitrary distinctions are lost sight of by which physical science is kept separate from abstract science. And yet to respect those restrictions seems often impossible because on close inspection they are unrecognizable.

Perhaps it is too much to hope that any restrictions at all can be formulated which can claim general recognition. We shall assume, however, that the field of physical science is restricted to those events whose unambiguous description is possible in terms of measurements made by rods and clocks.

In order to insure that a description shall deal with only one event at once we define "event" as something identifiable. And since if a thing has a break in its existence (*i.e.*, goes out of existence for awhile) it loses its identity, we assume that, by definition, discontinuous elements in events are excluded.

From this point of view the principle of indeterminacy is excluded from physical science, or, if tolerated, is regarded only as a temporary makeshift, and its introduction into scientific theories with the status of a "law" can lead only to confusion.

In retort it may be said that if no law can be tolerated which permits discontinuity in scientific processes then physical science is deprived of its only foundation, namely, the law that *an event which has happened before is likely to happen again.* Science fulfils the im-

portant function of prediction, by the use of this law, and yet by it the connection between events is one merely of likelihood or chance and the theory of probability becomes the foundation of scientific description. Faith in continuity is lost; we treat physical events as games of chance.

Thus the conclusion seems to be warranted that while the accepted definition of the field of physical science forbids a principle of indeterminacy, the fundamental law on which the scientific method is based does actually involve such a principle.

Now the official apology for the principle of indeterminacy recently introduced into atomic physics is this: Science defines reality as something unambiguously measurable. The velocity of an electron, when in a given position in an atomic orbit, is not measurable, hence there is "really" no such thing, and the principle must be accepted that an electron can not possess simultaneously both position and velocity.

If this be accepted then science becomes a game of chance and scientific theories must be built out of equations in probabilities.

The determinist may reply by showing that no game of true chance is possible and that, therefore, theories based on the principles of chance must be either makeshifts or delusions.

In a game of true chance the signs of successive throws must be undetermined in the sense that their causes have no systematic relation to the game. But if we look closely into the game, as for instance by analyzing two successive throws, we find a completely determined series of events. For instance, the vibration of the thrower's hand gives the penny a tilt as it rises; this tilt determines the number of somersaults and this gives sign to the throw. The succeeding throw starts in a manner determined by its predecessor, and so on. Thus the system or sequence of the causes of the signs of successive throws is disclosed.

The determinist may thus claim that since, on close investigation of the matter, he finds it impossible to conceive of measurements by which effects due to *systematically unrelated causes* can be recognized, there are in nature no such things.

The apparent impasse arises from a confusion. The scientific point of view is that it may be difficult but never can be impossible to find the systematic relation between events. This point of view is confused with the position in which actually we stand of being unable, by our very natures, to predict the future except as a probability. The notion is meaningless that we may experience future events without waiting for them. How we regard this fact is a matter of taste, but it is misleading to interpret it as a proof that the future is "undetermined." The future is unknowable but in all probability it is determined.

This ramble leads nowhere, but it encourages an attitude of unfriendliness towards atoms. The atom is the symbol of discontinuity. However small the atom may be, the mind pictures it with an "insides" which calls for investigation. The reality underlying nature can not be reached by way of the atom. The element of atomicity is burdened asymptotically, like the flea of the poem, and the mere numbering of its sub-elements must go on "ad infinitum," although it may be just as finite and comprehensible as the flea.

There is no warrant for the hope that finality of scientific knowledge of the physical world is attainable, but nothing forbids the hope, and it seems a pity to adopt a system like atomicity, one of whose rules is that finality shall be unattainable.

The alternative to atomicity and dis-

continuity is the field system. The human mind is not inquisitive about the "insides" of a line of force. A field of corn must have stalks—a sort of texture; a field of force, or a continuum need not. Common sense has no objection to the possession of properties by empty space (radio having made the idea familiar). Neither space nor time demand a texture whose threads call for investigation. Einstein's affiliation of space with time was the most mind-satisfying of all merely scientific ideas, and his unified field theory was the next logical advance; the quantum must shortly be drawn into it.

In the restricted sense of physical science and, therefore, with due deference to the "lap of the gods," complete knowledge of the non-living physical world is not forbidden. If it were reached then all the energies of the mind would be freed for the development of the more real world of the spirit.

The distinction between physical and spiritual is, no doubt, artificial and temporary, for it belongs to discontinuity, but human progress always has been by steps, and though each step has been false in content it has been true in trend and progress has been real.

THE PREVENTION OF CRUELTY AND THE WORK OF A GREAT HUMANE SOCIETY

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NATURE breeds life abundantly and destroys life remorselessly. Out of a sunlit sky a winged death falls like an arrow on its prey, and through the darkness death flits on silent pinions. From the branches of trees a furry death drops with tooth and claw, and among the grasses a scaly death with poisoned fang winds its serpentine way. Under the waters glides a finny death, and in the depths gay-colored death awaits with armed tentacles the life on which it feeds. Out of the North death strikes with cold blizzards and out of the South it rides the hurricane. From the storm clouds death sends its lightning, and from the sun issues death by heat stroke. With famine and thirst death reaps the harvest of life, and in the food she tenders to life lies death in poison, toxin and unbalanced and deficient nourishment. These are the clubs with which nature beats down life spectacularly.

More insidious and less spectacular, as a rule, are the weapons with which nature most often destroys the life she breeds. Death lurks in crawling ticks and mites and rides the air in mosquitoes and flies. It steals into its victims in worms that drain their life blood and sap their vitality. In protozoan parasites it enters the blood stream or invades the tissues. It resides in bacteria too small to see except with the microscope, and lies concealed in viruses that defy the microscope to detect them and the filter to stop them. And if these fail, an inevitable death walks hand in hand with an unavoidable old age.

These deaths stalk among the farmer's herds and flocks and take their yearly toll by hundreds of thousands. They filch from the farmer millions of dollars. And where death's weapons are too dull to kill, they leave their mark in unthriftiness and illness for which the animals pay in suffering and the farmer pays in lost income and costs of feed and treatment. To protect his animals from death and disease the farmer must throw around them as many safeguards as possible. They must be protected against inclement weather, against predatory animals, against famine and bad feed, against thirst and bad water and against disease.

To the deaths and suffering which nature inflicts must be added the deaths and suffering which man inflicts. Man is an animal, and as such he must feed as animals feed. He must eat animals or plants, and for the most part he either must eat animals or elects to eat animals as part of his food. His digestive tract is that of a meat-eater, a rather short and simple digestive tract suitable for the digestion of the concentrated food which meat provides. His simple stomach resembles that of the dog and is in marked contrast to the four-part stomach of the sheep and cow which provides storage in two relatively huge compartments for the large amount of grass which is hastily collected and later regurgitated and chewed in rumination. His small intestine is like that of the dog and is a short affair as compared with the 85-feet long intestine of the sheep. His large intestine and cecum, like those of the dog, are insignificant when contrasted with the enormous colon and cecum of the

horse with their many gallons of plant ingesta. Nature has laid on the human animal the compulsion to kill for his food, and while an individual here and there may elect to take the lives of plants only, instead of the lives of animals, the human race, by and large, eats meat and takes the lives of animals from necessity or choice. He must take life to live, or else follow nature's kill and live as a scavenger.

To a far lesser extent than nature, man inflicts suffering on animals. As a hunter he may wound game that gets away. In other fields he may neglect his domesticated animals, or abuse them with whip or spur. Needless cruelty has been too common. It is no far cry from our civilization to our former savagery. We are not remote from the time when man was a relatively weak animal surrounded by dangerous and powerful enemies, and when he had to strike back as best he could against cruel foes. In such circumstances it was unlikely that he would lament the blows he inflicted on the enemies that sought his life, nor is it surprising that he should still assert, sometimes remorselessly, the authority he has won against a hostile world that sought his destruction. He, too, is beset by death from fang and claw, from cold and heat, from famine and thirst, and from disease and old age. Against death from all these things except old age he must fight back if he is to survive in a world where life is still a struggle for existence.

But as man emerges from savagery to civilization he develops an increasing kindness and compassion. Self restraint leads him to avoid the infliction of needless suffering. Through education he develops kindness in children. By law he restrains those who would wilfully or carelessly inflict cruelty if left to themselves. These are the voluntary and imposed restraints on man to prevent cruelty by man.

But these cruelties inflicted by man are relatively few and isolated acts by comparison with the wounds which nature inflicts on the innumerable animals she spawns. In the endless battle of life with death, man can play only a small and carefully selected rôle. It is one thing to step between a man and the dog he intends to kick, but it is something else to interfere in the rolling tide of battle where individuals perish by millions daily. We have been none too successful in preventing the needless cruelty of recurrent useless human wars; we could only stop nature's destruction, if it were possible, at our peril. For death and decay are nature's devices for preventing an overcrowded world and making possible her endless experiment in the breeding of new life with the potentialities for new things. Without the intervention of death, a single species of many kinds of animals could very speedily overrun the world. It is no misfortune that man can not step into this whirl of death and bid life live immortally, for he would be buried in the swift flood of life that would rise from such an act.

Man's interference with nature's laws of life and death, his intervention to prevent suffering, must be selective and intelligent to the extent that we have attained intelligence. Could he deprive the tiger and eagle of their prey, he would only condemn tigers and eagles to suffer and perish from starvation, and any wide application of the vegetarian cult would condemn the carnivores and many omnivores to death. Could he save from birds and other animals the insect life that spawns so abundantly, he would not only starve the insect-eating birds and other animals, but he would bring on his head destruction from swarms of insects.

In most of his interference with nature, man seeks to benefit man. In self-defense he destroys carnivores and poisonous snakes. To protect his crops

he traps and poisons insects and rodents. To protect his livestock he builds shelter from storms, provides feed for winter and water for times of drought, dips cattle for ticks and sheep for scabies, practices swine sanitation to protect his swine from worms and filth-borne diseases, and in other ways prevents accidents and disease from injuring and killing the animals on which he depends for food, clothing and work.

Not to interfere with nature in the interest of man would be to subscribe to some fatalistic and esoteric doctrine that regards the welfare of man as of no importance or as something to be left to nature's discretion. Had primitive man adopted such an attitude there would have been no race of mankind to attempt such an attitude to-day. Primitive man fought against the forces that sought to destroy him, and modern man must do the same. If here and there some one wishes to take sides with nature, he can do so as an academic pastime, since the bulk of humanity will continue to behave in a way that protects these odd and exceptional persons. Such persons are dangerous only as they seek to make the rest of mankind conform to their peculiar philosophy.

Of the suffering and death which nature inflicts on man's livestock, the most important is inflicted by disease. To the casual observation of the humanitarian untrained in medical matters, the blow of a whip on a horse or the kick inflicted on a dog is an outstanding piece of cruelty that calls to heaven for interference. That such conduct calls for action to protect animals from cruelty and mankind from the sadistic psychology of cruelty is a matter of general agreement. But to the veterinarian or the thoughtful stockman the suffering from disease is a much more wide-spread and serious thing than the relatively rare infliction of cruelty on animals by brutal or careless persons.

The list of diseases from which animals suffer is a long one. The symptoms produced by disease are innumerable and sometimes extremely painful, as all persons who have suffered from certain diseases know. It is a painful thing to have a diphtheritic death clutch the throat and choke out the life, to have death grasp and still the heart, to suffer the fever and pain of peritonitis or the agony of trichinosis, or to die the terrible death of rabies or tetanus. But in one way the animal has the advantage over man. It does not know the concept of death nor have the realization that the end of life is approaching.

Numerous agencies have engaged in the effort to lessen the sum total of suffering and premature death among mankind and the lower animals. The church has preached kindness, the law has forbidden cruelties, and humane societies have intervened between oppressed and mistreated children and animals and their oppressors. These agencies deal with the small body of cruelties inflicted by man. Against the large body of cruelties inflicted by nature stand the great groups of physicians, veterinarians and scientists. Here are the groups that oppose nature's array of hostile forces when these forces are directed against man, his domesticated animals, his game and game birds, and his fur-bearers, fish and other useful animals.

In the warfare against disease the army of physicians and veterinarians maintains a force of combat troops on the firing line, the practicing physicians and veterinarians who engage disease and death at close quarters and fight for the health and lives of man and animals. A service of supplies brings to these troops the drugs, biologicals, new information and other weapons for the

attack on viruses, bacteria, parasites, poisons and the other troops which death marshals against man and his animals. And at the base are the ammunition factories forging old and new weapons for the fight. From tropical forests comes the material for the making of quinine for the combat with malaria, and from deep mines comes the arsenic from which will be made arsenicals for the combat on the far-flung fronts of syphilis, sleeping sickness, and cattle ticks and cattle-tick fever. In numerous laboratories, physicians, veterinarians and scientists quietly and persistently maintain the intelligence service which studies the forces of nature, spies upon her deaths and diseases to find the disposition of her lines and the weaknesses in her forces, and tests experimentally new weapons and new plans of attack on the captive forces of the enemy caged in test-tubes and experiment animals.

The world at large knows and appreciates the combat forces of the practicing physician and veterinarian. It understands that the materials for drugs are collected from far and wide and manufactured for the use of these combat forces. But it knows little of the research of the intelligence service that studies the forces of death and disease and plans new weapons. Now and then it learns from the press that a Lazear has died in a heroic proof that a certain mosquito carries the deadly yellow fever, that the field forces of the Public Health Service have lost three workers to the Rocky Mountain spotted fever with which they worked, that Francis and Lake have contracted the tularemia they were investigating, or that some courageous experimenter with radium has yielded an arm to the enemy on which he spied. For a moment a glimmer of appreciation of these soldiers of the secret service rises in the reader, but this soon dies down, and, when some fanatical opponent of this service approaches him with the tale that all such work has led to no result whatever, he carelessly puts his name to a petition that the laboratories be closed, and in so doing votes that disease and death be allowed to work their way with man and animal except as they may be fought with yesterday's weapons.

Foremost of those who would close the search for knowledge and write "Finis" to the rapidly growing book of medical science is the group of men and women who call themselves antivivisectionists. About a nucleus of paid propagandists clusters this medley of kindly but poorly informed humanitarians, enemies of all medical science, sadists who conceal under an outward love of animals a cruelty towards mankind, persons who boldly flaunt the conviction that they would rather see a child die of disease than have a guinea-pig subjected to experiment to find a way to save the child, persons who admit that they would rather see a million dogs die from parasitism at nature's hands than have a hundred dogs subjected to studies on that parasitism by scientists to save the million dogs, and persons whose qualification for passing judgment on medical work is the qualification of an advertising man, a minister, a poet, an author or an actress. This group is the outstanding group of nature's allies in the fight between man and nature's forces of disease and death. They are the enemy aliens who would blow up our laboratories and our ammunition plants, who would cut our service of supplies to the firing line, and who would leave our fighting forces to oppose to the incessant fire of nature's forces the ancient and rusty weapons of Hippocrates and Dioscorides. They do not hesitate to declare the immeasurable services of a Pasteur things of no value; they do not hesitate to tell the medical

man and veterinarian who have seen the deaths and suffering of rabies that there is no such thing as rabies; they do not hesitate to tell us who in childhood saw innumerable persons with faces scarred with smallpox pits and who now rarely or never see such faces, that vaccination is a crime. Year after year these persons hear the evidence of the benefits to mankind and to animals from experiments on animals and, year after year, with characteristic intellectual dishonesty, they reiterate the falsehood that no benefits ever came from experiments on animals. It means nothing to them that the disease and death which man deliberately inflicts on a hundred guinea-pigs or dogs to-day save the health and lives of a million persons or dogs or cows next year or in the next ten years. They cast their lot with nature's cruelties and disease and premature death on a large scale; the medical man and scientist cast their lot with man for the frustration of nature's cruelties and the prevention of disease and premature death on the large scale of nature. The antivivisectionists shut their eyes to nature's cruelties; they are not so concerned that man and animals suffer, but they are eager to lay their heavy hands on the work of scientists and to choke to death the sources of information as to how nature fights man and how man may best fight nature.

Whence came the weapons with which modern man fights nature's infliction of suffering, disease and death? Did any of them come from the antivivisectionists? Not one of them. They came from medical men and scientists. These are the workers who forged the weapons with which man fights smallpox, tetanus, anthrax, syphilis, tuberculosis, malaria and pellagra in man, and tick fever, blackleg, blacktongue and parasites of all sorts in his animals. The army of medical men and scientists on the firing line, in the service of supplies, and in the intelligence service asks the people whom it serves to protect that army in its fight against suffering, disease and death from the antivivisectionists who would deprive it of its weapons. It is preposterous that the medical men who have protected the public from birth, who have come to its rescue when nature struck at it with all the forces at her command, who have gone through the wintry night to sit at its bedside and bring it back from the shadow of death, should have to ask the public to protect it from the insidious attacks of a small minority of uninformed persons who ridiculously put out misrepresentations on the highly technical subjects of a medical science in which they are untrained and of which they are ignorant, but it is the inevitable weakness of democracy that highly vocal groups of persons may at will seek to impose their ideas on the public, and that numbers may outvote ability and competence.

The medical man must not only fight suffering, disease and death, but he must take from that fight the time and energy to fight ignorance and prejudice, the alien enemies who would tie his arms. And with characteristic logic the antivivisectionist resents the effort of the medical man and scientist to fight off these attacks. With astounding effrontery the leader of the antivivisectionists protested to the chairman of the senate committee in the District of Columbia at the hearing on the bill to prevent experiments on dogs, that government scientists came from their laboratories to oppose this bill which would stop their investigations of disease. Could illogical audacity exceed this assumption that scientists should sit abashed in their laboratories while women under the gonfalon of humanitarianism labored to persuade Congress to undermine the legislation which charged these scientists with the study of disease and the development of control measures?

In the lesser field of cruelties inflicted by man the humane societies of the United States have done an admirable work. In the greater field of cruelties inflicted by nature there is a great humane society that has done a wonderful work. That humane society is the federal Bureau of Animal Industry. Its record of achievement as a humane society has not been written, and it is here proposed to put that record on exhibition in contrast with the record of the antivivisectionists and as a record of work that supplements in preventing nature's cruelties the work which humane societies have done in preventing man's cruelties. There is no conflict between humane societies on one hand and scientists, physicians and veterinarians on the other; they supplement one another and they cooperate with one another. It is only between the antivivisectionists on one side and medical men and scientists on the other that war exists. It is true that the antivivisectionists have managed to enlist the support of many humane societies by representing the medical man and scientist as vicious, cruel and debauched persons who inflict wilful suffering to no purpose and for their own enjoyment. It is true that antivivisectionists have done this, but it is deplorable as the results of misrepresentation are usually deplorable. Let the humane societies judge the record of the Bureau of Animal Industry, one of the organizations which would suffer from antivivisectionist legislation, and say if the humane societies and the bureau are allies or enemies.

The Bureau of Animal Industry had its beginning in 1883 with the appointment of an able veterinarian and scientist, Dr. D. E. Salmon, as the head of a veterinary division. That same year it established two research units, a pathological laboratory and its experiment station. In 1886 it established the work in parasitology which later developed into its zoological laboratory, and in 1890 it established its biochemical laboratory. It is proof of Dr. Salmon's sagacity that at the very outset he took cognizance of the fact that our ability to combat disease was entirely dependent on our knowledge of disease, and that he should organize medical research to supply the vital information which we did not have for our attack.

Did anything of value to humanity, and especially to the farmer and stockman, come from these research laboratories? Let the following record answer the question.

In 1889 Dr. Kilborne obtained experimental evidence that cattle tick fever could be transmitted from cattle sick with this fever to healthy cattle by means of the cattle tick, *Boophilus annulatus*. In the same year Dr. Theobald Smith, of the Pathological Division, published the fact that the tick fever was caused by a protozoan organism in the blood, and he and Kilborne showed that the organism was transmitted through the egg of the tick which had fed on cattle sick of the fever. This brilliant and classical piece of work laid the foundation for the later work on the transmission of malaria and yellow fever by mosquitoes, sleeping sickness by tsetse flies, typhus fever by lice, Rocky Mountain spotted fever by wood ticks, tularemia by deer flies, and other disease agencies by insects and ticks. How was this work done? By animal experimentation. A few head of northern cattle were exposed to the bites of infected ticks, and these cattle sickened of the fever and showed the parasite in the blood. About the same time Dr. Curtice, of the Zoological Laboratory, ascertained the life history of the cattle fever tick—by animal experimentation. Subsequently Ransom and Graybill in the zoological division standardized the arsenical dip so that it would kill ticks

and would not kill the cattle which were dipped in it—by animal experimentation. Did these experiments on animals result in any benefit to man or animals? Consider these facts:

Tick fever had been enzoötic throughout the South for many years, and every year northern states suffered severe losses from the deaths of cattle exposed to the attack of ticks carried North in drives and shipments of cattle. The area in which tick fever was enzoötic, comprising all or part of fifteen states, was quarantined south of a line extending from Virginia to California and, in 1906, the systematic dipping of cattle to destroy ticks was begun by federal and state forces along the northern border of the quarantine line. At the present time tick fever and cattle ticks have been driven from eleven states and remain only in areas in four states, Florida, Louisiana, Texas and Arkansas. In 1905, the year before Congress made its first appropriation for federal tick eradication, the death losses from cattle tick fever were 387,500 head of cattle annually out of over 1,500,000 cases of tick fever. The losses from death, sickness and unthriftiness associated with cattle tick and cattle tick fever aggregated about $40,000,000 annually. Within 22 years after the inauguration of federal tick eradication, ticks and tick fever had been wiped out over an area of more than 500,000 square miles; to-day over 600,000 square miles have been released from quarantine. Experiments on the few animals used by the bureau had resulted in saving the lives and protecting the health of millions of cattle year after year. These experiments had saved the southern farmer millions of dollars annually and had enabled him to improve his stock in a way impossible under the menace of the tick. Within a few years cattle ticks and tick fever will be a thing of the past, and none of the South's cattle will ever know the suffering or experience the deaths that millions of cattle have suffered there from those things.

Does this mean anything to the antivivisectionist? No; he is committed to the statement that no good has ever come from experiments on animals, and he must not and can not admit that the classical work of Smith, Kilborne, Curtice, Ransom and Graybill has led to any benefit. He must and does contend that it was of no value. He must contend that Congress was deluded when it brought into existence a Bureau of Animal Industry that would experiment on animals as a basis for a brilliant campaign that has driven from most of the South the greatest menace to its livestock industry.

In 1896, shortly before these experiments on cattle tick and tick fever were undertaken, the antivivisectionists had introduced into Congress a bill to prevent experiments on animals. Could they have had their way they would have prevented this work, doomed the cattle of the South to many additional years of suffering and premature death, and condemned southern agriculture to share its livelihood with the tick and the fever. In 1930 they stood before Congress where they stood in 1896, on the platform that it is better for nature to destroy a million animals than for man to destroy a few and save millions. They had failed to stop the work on tick fever, but they hoped to stop future work. The scientist still stands where he stood in 1896, on the platform that if he can pay one life to save a hundred, a thousand or a million he will pay that life and save those lives. He realizes that nature still has many weapons against which we have no defenses, and that we can build those defenses only by experiments on animals.

In the control of hog cholera, the Bureau of Animal Industry has again

played the rôle of humane society. Hog cholera has been known in the United States for almost a century. As early as 1867 it caused the deaths of 15 to 60 per cent. of herds of swine in the area in which it occurred, and these deaths represented a loss of $15,000,000 to the farmer. In 1905, Dorset, McBryde and Niles, of the bureau, by experiments on swine developed a serum treatment for the protection of swine against hog cholera. This method of treatment by serum, or serum and virus, represents the only effective line of control in outbreaks of hog cholera. The sacrifice of the health and lives of a comparatively small number of swine has saved the lives of millions of swine and has saved the farmers millions of dollars. In 1913, before the division of hog-cholera control began work, over 6,000,000 swine, worth almost $60,000,000, died of hog cholera. In 1929, less than 2,000,000 swine, worth about $22,000,000, died of hog cholera. These comparative figures represent a saving of over 4,000,000 animals and $38,000,000. Will the antivivisectionists say that this work was of no value? Certainly they will. They are committed to the thesis that animal experimentation has never developed anything of value and any evidence to the contrary must be rejected by them.

A disease of horses known as dourine was imported into the United States in 1884, and by 1903 it had spread widely over the country. Its control was difficult because of our inability to detect it promptly enough to prevent its insidious spread. By animal experiments the bureau developed an effective complement-fixation test which has enabled it to eradicate this disease from most of the areas in which it was once present, and the small residuum of dourine in the western range horses will presently be wiped out. Will the antivivisectionists contend that the experiment animals should have been spared and the horse population of the United States allowed to suffer from our lack of the knowledge derived from animal experiments? They will.

Scabies in sheep is a disease which was known to the ancient world, and the use of scabby sheep as sacrifices to Jehovah is forbidden in the Bible. Thirty years ago scabies was the outstanding pest of the sheep industry of this country. It was absolutely ruinous to the wool crop and it killed large numbers of sheep, forcing many sheepmen out of business. Its cause, mode of transmission and its treatment were ascertained by animal experiments, some of them in the Bureau of Animal Industry. As a result of these experiments and the application of the knowledge obtained from them scabies has been eradicated from such important sheep-raising states as Montana, Idaho, Nevada, Oregon and Washington, and as a sporadic affair here and there it has fallen in importance far below many of the other sheep parasites for which we have inadequate control measures today. If we are to have control measures for these other parasites we must develop them as we developed control measures for scabies, by animal experiments, but the antivivisectionists would stop all experiments on animals as rapidly as their propaganda became effective, and leave sheep to die from blood-sucking worms. That the farmer would pay a heavy bill for this amazing form of alleged humanity does not matter to them. Let the scientist learn what he can by watching nature destroy sheep and guessing how she does it, but he must not produce disease under the controlled conditions which make possible a definite knowledge of how it is produced. Let the veterinarian treat sheep with such treatments as were known to Abraham, but forbid him to

test new treatments, for that is an experiment on animals. Such arguments may delude poets and actresses; it is unlikely that they will delude stockmen and farmers who suffer the losses from disease in their flocks and who have the pride in healthy and thrifty livestock that characterizes the sound husbandman.

At the beginning of this century tuberculosis in cattle was prevalent in every state of the union. At the Soldiers' Home in the national capital the milk supplied our veteran soldiers came from a herd of which 84 per cent. of the animals were tuberculous. By means of animal experiments in Europe, a diagnostic agent known as tuberculin was developed; by animal experiments in the bureau it was improved, and the Bureau of Animal Industry led the way in a nation-wide campaign to eradicate this disease. The herd at the Soldiers' Home was the first tuberculosis-free herd in the country. To-day the incidence of bovine tuberculosis is about one third of what it was in 1916. Three states are practically free from bovine tuberculosis, and in many states there are large numbers of clean herds and large accredited areas in which there are nothing but clean herds. There are 1,124 counties which are modified accredited areas with nowhere over 0.5 per cent. of tuberculosis. The per cent. of tuberculous cattle found at the packing plants has fallen off to one third of the amount previously found. Simultaneously there has been a sharp drop in the incidence of intestinal tuberculosis in children and other forms of juvenile tuberculosis, correlated with the decrease in the proportion of our supply of raw milk coming from tuberculous animals. This victory over the white plague was won with weapons developed by experiments on animals. Thousands of animals and persons have benefited for every experiment animal used. The antivivisectionist prefers tuberculosis to experimentation; normal persons in general will prefer that a smaller number of experiment animals die from tuberculosis that a larger number may live free from tuberculosis.

A somewhat similar story could be written about practically all the diseases of animals with which the Bureau of Animal Industry deals. Practically all the sound information we have in regard to the transmission and control of disease in these animals came from experiments on animals carried out either in the bureau or elsewhere. The bureau would not dare to ask Congress for money with which to start a tick-eradication campaign, a tuberculosis-eradication campaign, a hog-cholera-control campaign, or any similar campaign until it had this basic information from animal experimentation. Only after a control measure has been shown to work on experimental animals can it be recommended and put to work on a nation-wide scale. Irresponsible persons who need not account to the livestock industry for their ignorance can propose legislation to destroy the safeguards which the Bureau of Animal Industry throws around the livestock of the country, and if the legislation is enacted and disaster follows, these irresponsible persons can not be brought to task. The farmer would pay for their mistakes in cash and their animals would pay in suffering and death, but this would not worry the misguided enthusiast who wears the halo of the reformer. If they can make the world safe for experimental animals, disease in livestock may rage and agriculture be ruined. If the Bureau of Animal Industry makes mistakes it can be brought to account; it is a responsible organization, created by Congress, endowed with responsibility by Congress, and accountable to Congress. Will Congress, the American farmers and stockmen,

and the public support the Bureau of Animal Industry in maintaining the laboratories which have served them in the control of disease and have saved them millions of dollars, or will they take the word of antivivisectionists that these laboratories have achieved nothing and leave the antivivisectionists to prescribe the measures for the control of disease? Will the American people rush to the rescue of the scientist's guinea-pig or dog at the call of a frenzied antivivisectionist, and ignore the people, the livestock, the dogs and other animals that the scientist would save? Will they believe that all the testimony of the Bureau of Animal Industry, the Public Health Service, the American Medical Association, the American Veterinary Medical Association, the American Association for the Advancement of Science, and of other professional and scientific bodies that deal with science is false when these groups tell them that animal experimentation is the only means to learning the control of disease? Will they believe that Osler, Welch, Hektoen, Keen, Sternberg, Reed, Senn, McCoy, Stiles, Goldberger, Francis, Salmon and Mohler were liars when they testified what great good had come from experiments on animals? Will they believe the distinguished scientists Pasteur and Koch—or Mrs. Brown, Miss Jones and Mr. Smith, the antivivisectionists? Will they listen to evidence by the physician and veterinarian, or will they follow the war-whoop of the propagandists?

The humane societies of the United States put to death as painlessly as possible thousands of stray dogs annually, in order that these homeless animals may not suffer or perhaps perish more miserably than they do in the gas chamber. This is done as a kindness, and doubtless it often is a kindness, although under somewhat similar circumstances man prefers to cling to life, however miserable, and rarely elects death, voluntarily, as a release from the hardships of life. Probably if we consulted him, a homeless cur would elect to go his way and live from garbage cans. The problems of life for man or dogs are a bit complicated, and in a world of complications and uncertainties it is easy to mistake kindness for cruelty and cruelty for kindness. The antivivisectionist mistakes these things habitually.

The Bureau of Animal Industry, acting in its capacity as a humane society, also takes the lives of animals, but with less uncertainty as to benefits than is involved in destroying stray dogs, and with an objective which goes beyond that of our humane societies in general. In 1843, contagious pleuro-pneumonia of cattle entered the United States. In 1886, the young Bureau of Animal Industry had to drive this enemy of our livestock industry from the country. There was no cure for the disease. To eradicate it, the bureau killed every animal sick of the disease, the last animal being killed in 1892. From that year to this, there has been no contagious pleuro-pneumonia in the United States, and a vigilant quarantine by the bureau keeps that disease from the country. Had the bureau spared those cattle it slaughtered, there would have been by now almost 40 years of suffering and death among our cattle that have been averted by the bureau, almost 40 years of losses to the farmer that have been saved by the bureau. Was this destruction of sick cattle a humane and intelligent act? Does this compare favorably with the work of humane societies in general? Does it appear that the personnel of the bureau is interested in saving the lives of animals, or does it appear that it is composed of cruel and wanton persons?

On six occasions, the bureau has stamped out foot-and-mouth disease by slaughter in order that our herds might

be free from this disease. Is this humane? Would any humane society have acted differently? Yet the antivivisectionists ask the humane societies to believe that the bureau harbors a personnel that delights in cruelty.

There was a time when livestock was carried on freight trains for days without being unloaded, suffering from confined quarters and often inadequately provided with food and water. Did the humane societies abolish this practice? The one we have referred to as a great humane society, the Bureau of Animal Industry, did. Yet, under the pretense of a regard for animals, the antivivisectionist attacks the bureau as an inhumane organization.

There was a time when animals at packing plants were prodded and clubbed by stupid employees. The bureau stepped between these animals and their oppressors and forbade this cruelty. It insisted that animals for slaughter be handled humanely and killed as rapidly and painlessly as possible. Were these the acts of a cruel organization? No other humane society, nor all other humane societies together, can show so many animals protected from human cruelty as can the Bureau of Animal Industry. But the antivivisectionists would have you believe that the veterinarians and scientists of the bureau are fiends in human form.

Whether from the individual cruelty of man to animals, or from the thousandfold cruelties of nature to animals, the Bureau of Animal Industry protects many more animals than do any or all other humane societies. In its fight with human cruelty it invokes the law more surely than can other humane organizations. In its vastly greater fight with disease it uses whatever weapons are available. When science has afforded the weapons, it uses the dipping vat, tuberculin, serum, drugs, sanitation or other agencies. When there is no weapon from the research laboratory, as was the case with pleuro-pneumonia and foot-and-mouth disease, it uses the rifle. But there is no mistaking its objective. It was organized to protect the lives and health of animals, and that is its aim. Its regulatory work, its research, its experiments on animals, all have that goal in mind. Its procedures trace back inevitably to a research laboratory and to experiments on animals. To ban those experiments is to wreck its laboratories, and to wreck its laboratories is to destroy the foundation on which rests all its other work. The humane societies of the United States have the same goal as the bureau, the prevention of suffering, but the goal of the antivivisectionist is the prevention of knowledge of how to relieve suffering.

THE DIUTURNAL USE OF PERFUMES AND COSMETICS

By GRACE M. ZIEGLER
TRENTON N. J.

"Ladies, beauty is a Blessing of God, and every one ought to preserve it, in fine, they do as much offend that neglect it, as they do that Paint their Faces." This advice was offered in 1686 by Dr. Stephen Draper in an advertisement addressed to: "Beloved Women who are the Admirablest Creatures that ever God created under the Canopy of Heaven, to whom therefore, I have devoted my studies to the preserving of your Beauty, Health, Vigour, Strength and Long Life."

When one considers the annual cost of cosmetics for women, and men, too, throughout the ages, such counsel appears superfluous. The prodigious use of perfumes and cosmetics at the present time—running into hundreds of millions or perhaps billions of dollars—to secure a uniform standard of attractiveness might appear on the surface to be another instance of the modern trend toward standardization. That such a trend, so evident in the business world, is not responsible in this case is shown by the fact that a standard of personal beauty has been established and pursued as far back as any trace of human activity can be found. At times in the past this form of luxury far outstripped any present extravagance.

The tendency to legislate against any and every habit is another ancient custom, and it may be only a matter of time before another attempt is made to prevent the use of artificial aids to attractiveness. More than twenty-five hundred years ago a law was promulgated by Solon to prohibit the sale of fragrant oils to the men of Athens, and from then on similar bills have been introduced, among them one in England, in 1770, providing that:

> All women, of whatever rank, profession or degree, whether virgins, maids or widows, that shall from and after such Act, impose upon, seduce and betray into matrimony, any of his Majesty's subjects by the scents, paints, cosmetic washes, artificial teeth, false hair, Spanish wool, iron stays, hoops, high-heeled shoes, and bolstered hips, shall incur the penalty of the law now in force against witchcraft and like misdemeanours, and that the marriage upon conviction shall be null and void.

Although this did not become a law, it had a sobering effect upon the populace for a number of years. Surprisingly, Beau Brummel was opposed to the use of perfumes, on the ground that "No man of fashion should use them, but should send his linen to be washed and dried on Hampstead Heath."

From the earliest times, religion has vied with personal adornment in the consumption of perfumes. The use of costly ointment by Mary to anoint the feet of Jesus was but an echo of religious customs of the past. If sweet-smelling odors were so pleasing to man, would they not be the most effective method of propitiating the gods? That they were was a fixed belief for centuries, and there are many evidences that the use of perfumes and unguents formed an important part in the spiritual life of man.

A papyrus in the Hermitage Museum, said to have been written about 2000 B. C., contains in an account of the writer's journey into Nubia the statement:

> I will cause to be brought unto thee fine oils and choice perfumes, and the incense of the temples, whereby every god is gladdened. Of

myrrh hast thou not much; all that thou hast is but common incense. Ashipu came and delivered me, and he gave me a shipload of myrrh, fine oil, divers perfumes, eye-paint and the tails of giraffes.

One of the earliest recipes for making perfume, of which we have record, is given in the Book of Exodus:

Moreover Jehovah spake unto Moses, saying, Take thou also unto thee the chief spices: of flowing myrrh five hundred shekels, and of sweet cinnamon half so much, even two hundred and fifty, and of sweet calamus two hundred and fifty, and of cassia five hundred, after the shekel of the sanctuary, and of olive oil a hin; and thou shalt make it a holy anointing oil, a perfume compounded after the art of the perfumer: it shall be a holy anointing oil.

This oil was to be used for anointing the tent of meeting, the ark of the testimony, table and candlesticks, altar and laver, thereby making them holy so that whatever touched them became holy. Aaron and his sons were anointed with it, to minister unto Jehovah in the priest's office, but any one else who made or used a similar compound was to be "cut off from his people."

A recipe for incense is given in the same chapter:

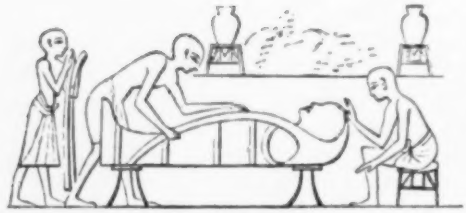
And Jehovah said unto Moses, Take unto thee sweet spices, stacte, and anycha, and galbanum; sweet spices with pure frankincense: of each shall there be a perfume after the art of the perfumer, seasoned with salt, pure and holy: and thou shalt beat some of it very small, and put of it before the testimony in the tent of meeting, where I will meet with thee: it shall be unto you most holy. And the incense which thou shalt make, according to the composition thereof ye shall not make for yourselves: it shall be unto thee holy for Jehovah. Whosoever shall make like unto that, to smell thereof, he shall be cut off from his people.

As perfumes were considered a most acceptable offering to the gods, vases were buried with the dead for their use in obtaining favor from the deities. Beautiful containers of alabaster and vases of diorite and other costly materials were provided with stoppers or lids to preserve the contents from deteriorating. The success of their elaborate efforts was shown when the opening of King Tutankhamen's tomb revealed exquisitely carved alabaster vases in which, after more than three thousand years had elapsed, the scent of the perfume still lingered.

We are told by Pierre Muret[1] that it was "an ancient Christian custom to perfume the body in commemoration of the spices in which the body of the Savior was wrapped, and that the pagans, who much prized perfume and used it in their religious rites and copiously on their bodies, much chided the Christians for wasting precious ointments on their dead at the expense of the living." The custom of perfuming the body of the deceased, however, was practiced many centuries before the time of Christ. The accompanying illustrations (Figs. 1 and 2) show the process of embalming Egyptian mummies, which for the richest people included filling the head with drugs and substituting for the intestines powdered myrrh, cassia and other perfumes (except frankincense). An address to the deceased, translated by Maspero, is as follows: "The perfume of Arabia hath been brought to thee, to make perfect thy smell through the scent of the god. Here are brought to thee liquids which have come forth from Rā to make perfect—thy smell in the Hall [of judgment]." It was thought that through the perfume the members of the body were made perfect.

The word "perfume" is from the Latin *per fumum*, meaning "through smoke." Doubtless the earliest use of perfumes was to serve as a means of communication with the gods, prayers being wafted upward on the sweet-smelling fumes, thus insuring more favorable reception. The Egyptians made a prayer to Rā that the souls of the de-

[1] Pierre Muret, (Tran. P. Lorraine), "Funeral Rites, Ancient and Modern."



PERFUMING THE BODY OF AN EGYPTIAN MUMMY
(FROM "THE BOOK OF PERFUMES" BY EUGENE RIMMEL. LONDON, 1865.)

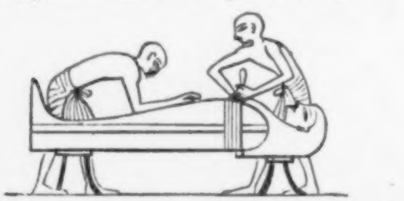
parted be carried to heaven on the smoke of the incense.

Perfumes also played an important part in many of the magical rites from the earliest times down to those practiced by the barbaric races to-day. In the sixteenth century Henry Bouguet discussed this subject under the heading "Of the Perfumes Used by Priests in their Conjurations."[2]

It remains for us to show that it is not out of place for our priests to use perfumes in their exorcisms: and this will be very easy. I will readily admit that perfume has no direct virtue against the Evil Spirit, since he has no body and consequently no sense of smell: Yet it must be granted me that this wicked Serpent is very glad to find in the bodies of men humours which the more dispose them to be tormented by him, the chief of these being the melancholy humour, which is of its nature apt to be heavy and sad; and therefore we find that those of a melancholy humour are more often possessed by a devil than are other men.

Now it is certain that there are perfumes which consume and correct these humours; for even sulphur works in a very subtle manner to that effect; and therefore I conclude that the Devil will be more easily cast out of a demoniac's body if it be purged of the humours of which we have just spoken, than if it be still charged with them. I am strengthened in this belief by the fact that Holy Scripture teaches us that the Evil Spirit is more glad to be in one body than another, as we see in St. Mark, where the devils, being commanded by Jesus Christ to come out of a man's body, asked to be sent into some swine. It follows, therefore, that the perfumes of our priests must not be decried, since they are, in some manner, of use against devils. This is even better shown by the example of the youth Tobias, who drove away the Devil with a perfume which he composed from the heart and liver of a fish. It is true that he accompanied this with prayers and fasting; but do not our priests the same? There is no doubt, also, that perfumes which are hallowed by the Word of God are of greater virtue against the Devil than such as are used in their own natural state; and therefore Origen, speaking of perfumes and incense, says that the sanctification by the Word of God, with Holy Prayer and the help of the Angels, is the reason for perfume and incense driving out demons.

But who will contradict me when I say that God endows these perfumes with a supernatural power against demons and their works, seeing that we have already mentioned certain stones and herbs which drive away all spells and enchantments? For that He may the more manifest His Majesty, God wishes to fight and overcome demons by means of these insignificant things, just as He put Pharaoh's magicians to shame when they tried to create flies; for although they, as well as Moses, had made frogs and serpents and dragons, yet they could not succeed in making these small and minute little creatures.



BINDING THE BODY OF AN EGYPTIAN MUMMY AFTER IT HAD BEEN PERFUMED
(AFTER RIMMEL.)

Other purposes, too, have been served by the use of perfumes. Society ladies in the eighteenth century are said to have "painted their faces instead of washing them, and mitigated the effects of seldom-changed underclothing by copiously drenching themselves with musk and other reliable perfumes."

Two centuries ago the pompous doctors carried musk, camphor or other aromatics in the hollow handles of their walking sticks to hold to their noses and protect themselves from the dangers of infection. In medieval, Jacobean and Georgian medicines, fumigation was a

[2] Henry Bouguet, "An Examen of Witches," Lyons 1590? Trans. E. A. Ashwin, New York, 1929.

favorite remedy. Perfumes and aromatics were extensively used in the medicines in those days.

As "Cures for Head-Melancholy" Robert Burton in "The Anatomy of Melancholy" prescribes:

Odoraments to smell to, of rose-water, violet flowers, balm, rose-cakes, vinegar, &c., do much recreate the brains and spirits, according to Solomon. Prov. XXVII. 9, "They rejoice the heart," and, as some say, nourish: 'tis a question commonly controverted in our schools, *an odores nutriant*: let *Finicus, lib. 2, cap. 18.* decide it; many arguments he brings to prove it; as of Democritus, that lived by the smell of bread alone, applied to his nostrils, for some few days, when for old age he could eat no meat. Ferrerius *lib. 2. meth.* speaks of an excellent confection of his making, of wine, saffron, &c., which he prescribed to dull, weak, feeble, and dying men to smell to, and by it to have done very much good, as if he had given them drink.

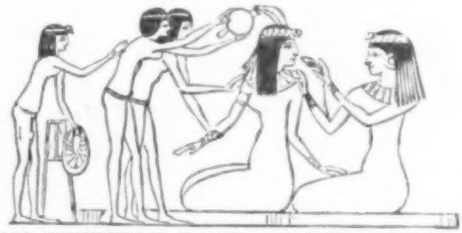
Irrigations of the head shaven, of the flowers of water-lilies, lettuce, violets, camomile, wild mallows, wether's head &c. must be used many mornings together.

Lælius à fonte Eugubinus, *consult 44*, for an Italian count troubled with head-melancholy, repeats many medicines which he tried, but two alone which did the cure; use of whey made of goat's milk, with the extract of hellebore, and irrigations of the head with water-lilies, lettuce, violets, camomile, &c. upon the suture of the crown.

Unto the heart we may do well to apply bags, epithemes, ointments, of which Laurentius, *C. 9, de melan*, gives examples. Bruel prescribes an epitheme for the heart, of bugloss, borage, water-lily, violet waters, sweet wine, balm leaves, nutmegs, cloves, &c.

Among the remedies employed against the plague were many containing sweet essences and aromatic oils, and it is said that the plague water and essences gave the initiative for the invention of Eau de Cologne by the Italian, Johann Maria Farina, who first prepared it at Cologne about 1700. The essences and aromatic oils were evaporated on glowing bricks; whole houses were rubbed down with them, and they were poured on handkerchiefs to be inhaled in the streets. Sometimes incense, juniper berries, lemon and orange leaves, rosemary, lavender, myrrh, etc., were burned in rooms to kill the plague. Scent boxes were sold for use on going out, and some prescriptions called for a scent box for every day in the week, each containing different essences, which were placed on a little sponge. Roses, cloves, juniper, rosewood, sandalwood, lemon peel, etc., were used either as extracts or solids.

The use of perfume for personal pleasure dates from prehistoric times. In the early days it was rivaled as an example of conspicuous waste only by the adornment with precious jewels. As a means of allurement it is apparently without a rival. No one questions the power of an unpleasant odor to repel and nauseate a person, but it is seldom considered that a pleasant odor may



AN EGYPTIAN LADY AT HER TOILET
(AFTER RIMMEL.)

have as strong a power to attract. However, in all forms of life scent is thus employed. Flowers send forth their perfumes that insects may be attracted and made to carry out their activities as pollinators. Certain animals from which the "fixatives" in our own perfumes are derived are provided with peculiar scents to attract others of their kind. Japanese beetles and other injurious insects are lured to their death through the artificial employment of their favorite scent.

Pliny in his "Natural History" considered the unselfishness of the person using perfumes.

These perfumes [he wrote] form the objects of a luxury which may be looked upon as being the most superfluous of any, for pearls and jewels, after all, do pass to a man's repre-

sentative, and garments have some durability; but unguents lose their odour in an instant, and die away the very hour they are used. The very highest recommendation of them is, that when a female passes by, the odour which proceeds from her may possibly attract the attention of those even who till then are intent upon something else. In price they exceed so large a sum even as four hundred denarii per pound: so vast is the amount that is paid for a luxury made not for our own enjoyment, but for that of others; for the person who carries the perfume about him is not the one, after all, that smells it.

Thousands of years ago the trade in aromatic gums and sweet-scented oils formed an important item of commerce between Egypt, Arabia, India and Syria, and they were valued equally with gold and silver. Egyptian splendor was replete with perfumes and scented unguents. Houses were perfume scented; the people were commanded to perfume themselves every Friday; food, wines and delicacies were flavored with perfume; during festivals incense was burned in the streets to permit even the poor to enjoy the exquisite fragrance; the men used scented unguents for their bodies and the women bathed in perfumed waters. The guests at banquets were met by slaves whose duty it was to anoint their heads with perfumed unguents and hang chaplets of lotus around their necks. Perfumes continued to grow in favor until in Cleopatra's time it is not surprising that she used them lavishly to add to her allurements and charm. It is said that "She used the worth of 400 denarii of spices but once, to anoint her hands, which was wafted away on the air and lost for ever." Of the barge she used when sailing down the River Cydnus to meet Mark Antony, Shakespeare writes:

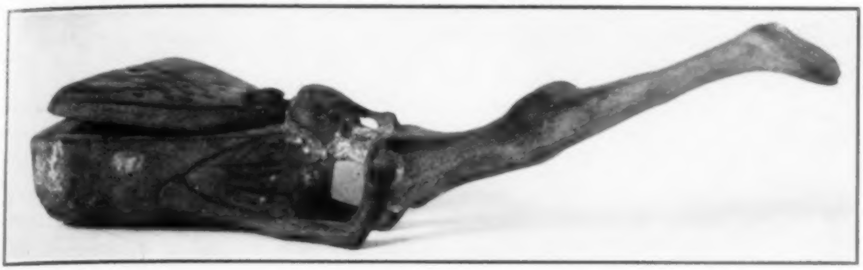
Purple the sails, and so perfumed that
The winds were love-sick . . . .
From the barge
A strange invisible perfume hits the sense
Of the adjacent wharfs.

Kyphi was the most celebrated of Egyptian perfumes, for the making of which several recipes have been discovered. Honey, wine, cyprus, myrrh, saffron, dock and juniper are among the sixteen ingredients given in the recipe handed down by Plutarch, of which he writes: "Its aromatic substances lull to sleep, allay anxieties, and brighten the dreams. It is made of things that delight most in the night and exhibits its virtues by night." In addition to furnishing an agreeable odor to the body and clothes, Kyphi was burned in the house to perfume the air, and was used as a medicine.

Cosmetics were employed lavishly by Egyptian women, who deemed it essential to anoint their eyelids each day with an unguent. Eyebrows were darkened with eye-paint that varied according to the seasons of the year. Cheeks and lips were rouged with red ochre, and among the richer classes both finger and toe nails were stained with henna juice to give a reddish yellow appearance. Even after death the faces of women of high rank were colored and their eyelids and eyebrows were darkened with antimony. Another beauty preparation, used by a queen of the third dynasty, was to benefit the hair, the prescription for which was contained in the Ebers Papyrus and consisted of equal parts of the heel of an Abyssinian greyhound, of date blossoms, and of asses' hoofs, boiled in oil. Perfumed oil was poured over the hair before it was combed and the coiffure arranged.

The Arabs carried on a heavy trade in perfumes, spices and aromatic oils, and they too used perfumes extravagantly. A recipe for a marvelous pie, described by Abd-El-Lateef, is as follows:

Thirty pounds of fine flour are kneaded with 5½ pounds of oil of sesame and divided into two equal portions. Upon one place three lambs stuffed with meat, fried with oil of sesame and ground pistachio nuts, and various hot aromatics, as pepper, ginger, cinnamon, mastic, coriander seed, cumin seed, cardamons, and nutmeg. These are to be sprinkled with Rosewater infused with musk, and upon the lambs



AN EGYPTIAN TOILET BOX MADE OF WOOD, IN USE ABOUT 1500 B. C.
(IN THE UNIVERSITY OF PENNSYLVANIA MUSEUM.)

are to be placed 20 fowls, 20 chickens, and 50 smaller birds, some of which are to be baked and stuffed with eggs, and some with meat, and some fried in the juice of sour grapes or limes. A number of small meat pies are then to be added and others filled with sugar and sweetmeats. The whole is then to be piled up into a dome, and rose-water infused with musk and aloeswood sprinkled over it. Then the other half of the pastry is to be placed over the top and the pie closed and baked, after which it must again be sprinkled with rose-water infused with musk before it is eaten.

The Greeks were as lavish in the use of perfumes as were the Egyptians. Their use was thought to have originated with the gods, and Greek mythology contains many references to the gods who were enchanted by delightful odors. However, the Greeks quickly adopted this luxury for their own, using it also in their foods and wines, for which roses and violets were preferred. At banquets, to ward off the effects of the wine, the guests anointed their heads with unguents made from roses, apples, iris or spikenard. Perfumes were disseminated throughout the banquet hall, and one interesting method is quoted by C. J. S. Thompson[3] in which doves were used:

He slipped four doves, whose wings were saturate
With scents, all different in kind—these doves,
Wheeling in circles round, let fall upon us
A shower of sweet perfumery, drenching, bathing,
Both clothes and furniture and lordlings all.
I deprecate your envy when I add,
That on myself fell floods of violet odours.

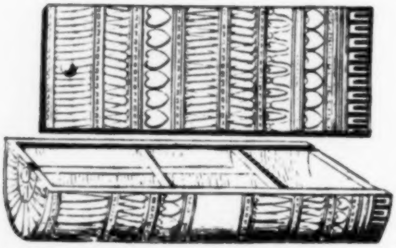
The Greeks used chests of perfumed woods to store their clothing, and the most fashionable people used a special scent for each part of their body. A bath of this kind is described by Antiphanes:

In a large gilded tub he steeps his feet
And legs in rich Egyptian unguents,
His jaws and breasts he rubs with thick palm oil,
And both his arms with extract sweet of mint,
His eyebrows and his hair with marjoram,
His knees and neck with essence of groundthyme.

The use of perfumes was carried to such excess in Athens that a law prohibiting the sale of fragrant oils to the

AN IVORY TOILET BOX USED BY EGYPTIAN WOMEN ABOUT 3400 B. C.
(IN THE UNIVERSITY OF PENNSYLVANIA MUSEUM.)

[3] C. J. S. Thompson, "The Mystery and Lure of Perfume." Philadelphia, 1927.



AN EGYPTIAN OINTMENT BOX WITH COMPARTMENTS
(AFTER RIMMEL.)

men of the city was passed. Nevertheless their fondness for this form of luxury persisted, and nearly two hundred years later Socrates deplored the custom by writing:

> No man is ever anointed with perfume for the sake of men, and as to women, how can they want perfume in their husbands when they themselves are redolent of it? If a slave and a freeman be anointed with perfume, they both smell alike in a moment, but those smells which are derived from free-labours require both virtuous habits and a good deal of time, if they are to be agreeable and in character with a freeman.

In spite of Socrates' antipathy to perfumes it has been recorded that one of his pupils turned perfumer, got into debt and tried to borrow money on the strength of his business.

The fashion of anointing the head at banquets is said to have arisen from the idea that the heating effects of the wine could be better borne if the head were wet. An unpleasant result of this custom, however, is mentioned by Aristotle, who attributed the frequent occurrence of gray hair to the drying nature of the spices used in the unguents.

PERFUME BOTTLES USED BY THE ROMANS
(AFTER RIMMEL.)

Among Romans the passion for perfumes was unbridled. After the conquest of Egypt, India and Arabia, enormous supplies of perfumes were obtained from them in addition to those secured from Italy and Gaul. These they used profusely in their baths, their bedrooms and their beds. The Romans, like the Greeks, had perfumes for different parts of the body, and each man, woman and child perfumed himself on leaving his bed, after the bath, and after meals. Clothing was saturated with essences, and aromatic spices were burned day and night. The trade of perfumers and unguentarii made rapid progress, and the vegetable and animal and mineral kingdoms were searched far and wide so that oils, pomades, balms, pastes, powders, cosmetics and aromatic substances could be found.

Pliny wrote:

> I can not exactly say at what period the use of unguents first found its way to Rome. It is a well-known fact, that when King Antiochus and Asia were subdued, an edict was published in the year of the City 565, in the censorship of P. Licinius Crassus and L. Julius Caesar, forbidding any one to sell exotics; for by that name unguents were then called. But, in the name of Hercules! at the present day, there are some persons who even go so far as to put them in their drink, and the bitterness produced is prized to a high degree, in order that by their lavishness on these odours they may thus gratify the senses of two parts of the body at the same moment. It is a well-known historical fact, that L. Plotius, the brother of L. Plancus, who was twice consul and censor, after being proscribed by the Triumvirs, was betrayed in his place of concealment at Salernum by the smell of his unguents, a disgrace which more than outweighed all the guilt attending his proscription. For who is there that can be of opinion that such men as this do not richly deserve to come to a violent end?

Discussing the kinds of unguents used by the Romans, Pliny said:

> And yet, even here, there are some points of difference that deserve to be remarked. We read in the works of Cicero, that those unguents which smell of the earth are preferable to those which smell of saffron; being a

proof that even in a matter which most strikingly bespeaks our state of extreme corruptness, it is thought as well to temper the vice by a little show of austerity. There are some persons too who look more particularly for consistency in their unguents, to which they accordingly give the name of "spissum"; thus showing that they love not only to be sprinkled, but even to be plastered over, with unguents. We have known the very soles even of the feet to be sprinkled with perfumes; a refinement which was taught, it is said, by M. Otho to the Emperor Nero. How, I should like to know, could a perfume be at all perceptible, or, indeed, productive of any kind of pleasure, when placed on that part of the body? We have heard also of a private person giving orders for the walls of the bath-room to be sprinkled with unguents, while the Emperor Caius had the same thing done to his sitting-bath: that this, too, might not be looked upon as the peculiar privilege of a prince, it was afterwards done by one of the slaves that belonged to Nero.

At one of his famous festivals Nero is said to have spent four million sesterces, or about $200,000, for roses and perfumes, and for the funeral of Poppæa he used more perfumes and incense than could be produced in a whole year in Arabia, which at that time was their chief source of supply.

To conserve the supply of fragrant materials for religious use, an attempt was made to curtail the use of perfumery under the Consulate of Licinius Crassus by passing a law. Whether this law was strictly enforced is unknown. However, a few years later Ovid told women how to acquire a beautiful complexion, the recipe for which was given in a part of a book that still remains.

Learn from me the art of imparting to your complexion a dazzling whiteness. Divest from its husk the barley brought by our own vessels from the Libyan fields. Take two pounds of this barley with an equal quantity of bean-flour, and mix them with ten eggs. When these have been dried in the air, have them ground and add the sixth part of a pound of hartshorn. When the whole has been reduced to a fine flour, pass it through a sieve, and complete the preparation with twelve narcissus bulbs that have been pounded in a mortar, two ounces of gum, as much Tuscan-seed, and eighteen ounces of honey. Every woman who spreads this paste on her face will render it smoother and more brilliant than her mirror.

In another work, Ovid's advice was:

Rouge a pale cheek, a red one powder,
Each maiden knows that art's allowed her.

He, however, added the caution:

But do not let your art be seen
Your lover must not even find
A powder-puff behind a screen
Or come upon you from behind
When the cold cream is oozing down
And moistening your dressing-gown.

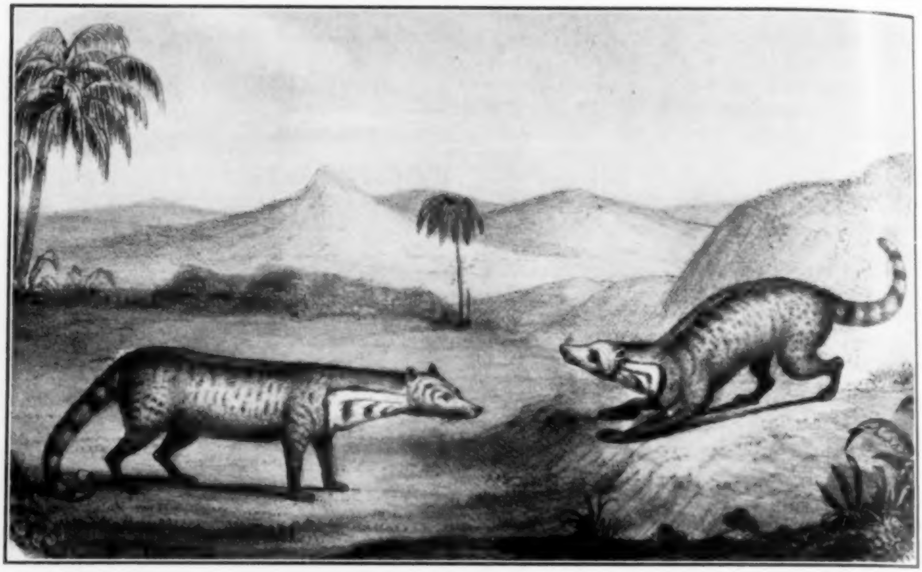
A Roman dinner, at which Julius Cæsar was a guest and Mucius Lentulus Niger the host, was described by Arthur Weigall[4] as follows:

A PERFUMER'S SHOP IN MEDIEVAL TIMES
(AFTER RIMMEL.)

The diners lay upon couches usually arranged around three sides of the table, and they ate their food with their fingers. Chaplets of flowers were placed upon their heads, cinnamon was sprinkled upon the hair, and sweet perfumes were thrown upon their bodies and sometimes even mixed with wines. During the meals the guests were entertained by the performances of dancing girls, musicians, actors, acrobats, clowns, dwarfs, or even gladiators.

The menu at this dinner was in keeping with the entertainment. It included sea-hedgehogs, oysters, mussels, sphondyli, fieldfares with asparagus, black and white sea-acorns, glycimarides, sea-nettles, becaficoes, hares, teals, peacocks, cranes, etc., etc.

4 Arthur Weigall, "The Life and Times of Cleopatra," New York, 1924.



THE CIVET CAT
(FROM AN EARLY AMERICAN LITHOGRAPH.)

Other countries were scarcely less lavish in their use of perfumes, as shown by numerous references to their customs. It is said that Antiochus Epiphanes, King of Syria, employed two hundred women to sprinkle spectators at games held at Daphne with perfumes from golden vessels. Alexander the Great had the floors of his apartments sprinkled with perfumes, while myrrh and other aromatic gums were burned in his halls. A sacred fire, fed with sandalwood, perfumed oils and incense, was kept burning during the Hindu marriage ceremony. The Muslims of India rubbed their faces and bodies with perfumed powders, two favorites being "Abeer," which was made of roses, aloes-wood, sandalwood, turmeric, camphor, and civet, and "Chiksa," composed of patchouli, sandalwood, mustard seed, flour, foenugreek, cyprus, kuskus, aniseed, camphor and benzoin. The bridegroom usually presented his bride with a toilet bag containing "a box to hold betel-nut for chewing, a small bottle of attar of rose, a bottle to sprinkle Rose-water, a box for spices, a box for meesu, a powder consisting of galls and vitriol for blackening the teeth (customary for married women), a box for powder to blacken the eyelids, and one for Kajul (similar to Kohl) for darkening the eyelashes, together with a comb and other toilet necessaries." Incense burners form a part of the household equipment of the Chinese. Musk is their favorite perfume and is obtained from musk-deer on their mountains. The fondness for perfumes and cosmetics in Carthage is well illustrated in Flaubert's "Salammbo" by his description of Hamilcar's visit to his perfume room, presided over by a chief of perfumes.

Naked men were laboriously engaged kneading pulp, pressing herbs, stirring the fires, pouring oil into jars, opening and closing little oval cells excavated all around in the walls, which were so numerous that the room resembled the interior of a beehive. Myrobalans, bdellius, saffron, and violets overflowed the place, and all about were gums, powders, roots, glass phials, branches of dropwort and rose petals; the scents were stifling, in spite of the clouds

> from the storax that crackled in the centre on a brass tripod. The Chief of Perfumes, pale and very tall, like a wax torch, came forward to greet Hamilcar by crushing over his hands a roll of aromatic ointment, whilst two slaves rubbed his heels with harewort leaves.

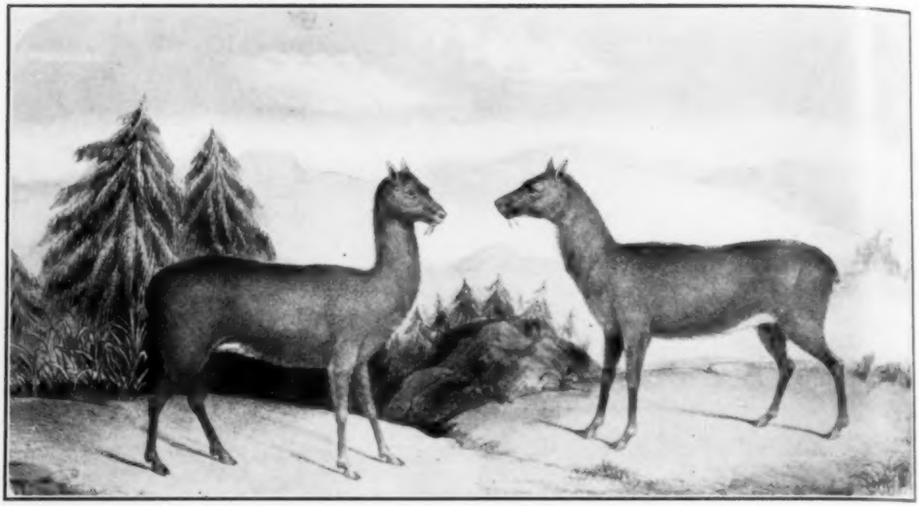
The servant of Hamilcar's daughter "tinted with henna the inside of the hands of her mistress, touched her cheeks with vermilion, put antimony on her eyelids, and lengthened her eyebrows with a mixture of gum, musk, ebony, and crushed flies' feet." (It is interesting to note that crushed flies were recommended for the fashionable toilet in England in the sixteenth century, when Thomas Moffet wrote in his book on insects: "A Maid that cares for her beauty, and would make the circles of her eye-lids black, Emmets eggs bruised with Flies will perform that, and give them their desire.")

After the fall of the Roman Empire the use of perfumes declined, although the barbarians who invaded western Europe would have been greatly benefited by the perfumed baths that had charmed their predecessors. Perfumes were again brought to Europe by the Crusaders, but due to religious persecution experiments in perfume-making, as in science, had to be made in secret to avoid charges of witchcraft. With the coming of the Renaissance, perfume regained something of its former popularity.

For many years Italy was foremost in the art of perfumery, supplying the rest of Europe with sweet bags, perfume cakes to be thrown on fires, fragrant candles and cosmetics, scented gloves and pomanders. But when in 1533 Catharine de Medici went to France to marry the Duke of Orleans, afterward Henry II, there was in her entourage an expert Florentine perfumer named René, and also an astrologer and alchemist who was given an apartment that was connected with the queen's by a secret staircase, and who was thought to have supplied her not only with sweet essences and perfumes but with many of the poisons and potions used by her in carrying out her political intrigues. It was René, however, who revolutionized the perfume industry in France, which had been carried on up to that time in a desultory fashion, although as early as the twelfth century it was important enough to require that perfume-makers be given charters. René's shop became the rendezvous of the fashionable world. Other Italian masters were soon attracted to France by the concessions and patronage of her kings, and in a short time the country gained the supremacy that she still maintains. It became the custom for many of the higher classes to superintend the making of their own favorite perfumes, and many had still-rooms in their homes. Louis XIV was a devotee of this art, receiving his perfumer, Martial, in his private closet for this purpose. Perfume bellows were used to diffuse sweet-smelling powders through the rooms, and Cardinal Richelieu liked his rooms scented in this manner. Madame de Pompadour's yearly perfume bills mounted as high as 500,000 livres (nearly $100,000).

Under Queen Marie Antoinette the more delicate scents of the violet and rose came into use and have retained their popularity. The perfumed baths were revived in the latter part of the eighteenth century, and Madame Tallien's favorite bath was one of crushed strawberries and raspberries, after which she was rubbed with sponges soaked in perfumed milk. Perfumed gloves made their appearance in France in the sixteenth century. To make them, the perfume materials were mixed with a fatty basis and smeared on the inside of the gloves and this also served to keep the skin soft.

Napoleon was lavish in his use of perfumes. Aloes-wood and Eau de Cologne



THE MUSK DEER
(From an early American lithograph.)

were his favorites, the latter being used when washing, and poured with an unsparing hand over his neck and shoulders to the extent of sixty bottles a month. His perfume bills were enormous. Josephine, too, was inordinately fond of perfumes, but she preferred the strong-smelling essences. Her dressing room was so redolent with her favorite, musk, that Napoleon is said to have frequently objected, and repeated washings and paintings failed to extinguish the odor.

England, perhaps, never became so enthusiastically addicted to the perfume habit, her habitual restraint tending to curb any extravagance comparable to that of France and the older countries. It was France that gave England her first real taste of this luxury, when in the tenth century Hugh the Great, seeking in marriage the sister of King Athelstan, sent her gifts of perfume "the like of which had never before been seen in England." Fragrant gums and spices were first imported into England by the Guild of Pepperers, which is mentioned in the Pipe Rolls of London in 1179. They were traders or merchants who imported medicinal and other spices from the shores of the Red Sea and various western ports. There was also another group called "Spicers." In the thirteenth century, groups of traders congregated together and their stalls were often located together in the markets, a convenience for traffic and in the adjustment of prices.

The general use of perfumes in England began in the Tudor times. Rose water, however, had been used for many years for washing the hands after banquets, a custom probably partly due to the fact that forks were considered foppish until after James I's reign. Perfumed gloves were first used in England about 1550, and Queen Elizabeth was so delighted with a pair she possessed that she had herself pictured wearing them. Every country house had its still-room, and each lady of quality had her own recipe for perfumes and domestic medicines. No perfumer is recorded in London until the seventeenth or early eighteenth century. Then Charles Lilly, the famous perfumer, prepared and marketed in his shop in the Strand "snuffs and perfumes which refresh the

brain in those that have too much for their quiet, and gladdens it in those who have too little to know the want of it."

Regardless of the Rev. Thomas Tuke's book published in 1616, entitled, "A Treatise against Painting and Tincturing of Men and Women: against Murther and Poysoning: Pride and Ambition: Adulterie and Witchcraft; and the Roote of all these, Disobedience to the Ministery of the Word. Whereunto is added, The Picture of a Picture, or, The Character of a Painted Woman"—regardless of this, chemists opened shops immediately afterward and sold hair-lotions, powders for the teeth, and aromatic waters such as lavender, elder-flower and rosemary. The wearing of black patches became fashionable at this time, and this fad reached such proportions that on June 7, 1650, a bill was introduced into the House of Commons (but failed of passage) to prohibit "the vice of painting, wearing black patches and immodest dress of women." It will be remembered that Samuel Pepys always spoke with pride of the black patches which were the smart feature of his wife's dress for formal occasions.

Perfuming the person as well as the clothes came into practice in England in the eighteenth century, along with carrying the handkerchief in the hand and the use of the cane. Powdering the hair was another method of adornment at this time, but in 1795 a guinea tax on each person thus embellished was responsible for a boycott on hair powder. The person continuing its use was thereafter called a "guinea pig" and became an object of mirth. In spite of their legal measures to restrain the use of these non-essentials, perfumes and cosmetics continued in fashion, and in 1828 King George IV had perfume bills amounting to £500 17s. 11d.

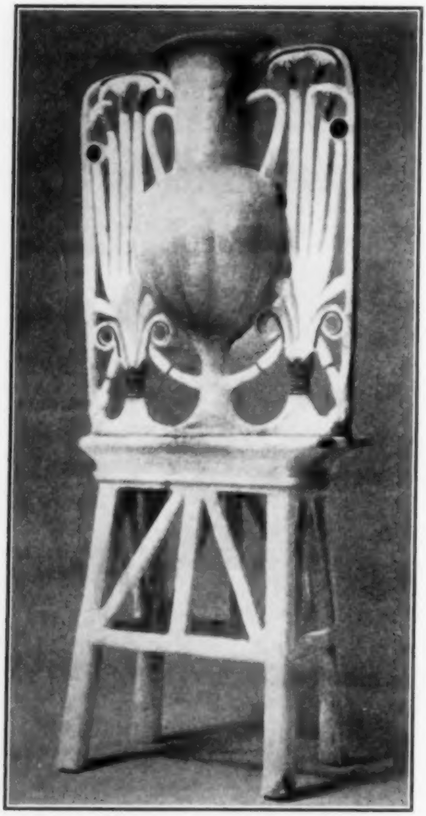
Perfume-makers were enriched by the discovery of America, when additional stores of sweet-smelling plants, such as the balsam of Peru, cacao, vanilla and others, became available. To the struggling pioneers who settled in America, however, these meant nothing. For many years there was not the leisure nor the money nor the transportation facilities to permit the enjoyment of such a luxury. Nevertheless, by 1832 the women were giving more thought to the enhancement of their charms if one may accept Frances Trollope's statement in her book on the "Domestic Manners of the Americans."

> The ladies have strange ways of adding to their charms. They powder themselves immoderately, face, neck and arms, with pulverized starch; the effect is indescribably disagreeable by day-light, and not very favourable at any time. They are also most unhappily partial to false hair, which they wear in surprising quantities; this is the more to be lamented, as they generally have very fine hair of their own.

The stride from this beginning has been unbroken, but recently it has developed into a pace so rapid as to be astounding. Estimates from tax returns showed an increase of $100,000,000 in the sale of perfumes and cosmetics from 1920 to 1924, and if figures were available since that time the increase would be far more startling. A recent unofficial estimate of the Department of Commerce placed the annual expenditure for cosmetics and beauty care in the United States at nearly two billion dollars.

The earliest perfumes used were the dry, resinous gums secured from fragrant trees—myrrh, frankincense, spikenard, galbanum and others. Lack of knowledge regarding spirits of wine or strong alcohol in which to dissolve the essential oil limited the early perfumes to those which could be made with a basis of olive oil or oil of Behn, and these were called unguents or ointments. Flowers gradually came into use, and by the time the Greeks came into power the iris, rose, crocus and violet were popular.

The first scent to be extracted through the process of distillation was rose water.



AN ALABASTER PERFUME VASE FOUND IN THE TOMB OF KING TUT.ANKH.AMEN.
(FROM "THE TOMB OF TUT.ANKH.AMEN" BY HOWARD CARTER AND A. C. MACE, NEW YORK, 1923.)

In 810 A.D. a tribute of 30,000 bottles of rose water was sent from the Persian province to the treasury of Bagdad, and rose water has continued to maintain its popularity through all the centuries following. About 1393 a "citizen of Paris" gave a recipe for making rose water, in a book entitled "Le Ménagier de Paris."[5]

> To make Rosewater without Lead Alembic take a barber's basin, and cover it with a kerchief spread right over the mouth in the manner of a drum, and then lay your roses on the kerchief, and above your roses set the bottom of another basin filled with hot cinders and live charcoal.
>
> To make Rosewater without either Lead Alembic or Fire take two glass basins and do as is said at the back of this page [*i.e.* above] and instead of ashes and charcoal, set it in the sun; and in the heat thereof the water will be made.
>
> The roses of Provins be the best for putting in dresses, but they must be dried and sifted through a sieve at mid-August so that the worms fall through the holes of the sieve, and after that spread it over the dresses.

[5] Trans. by Eileen Power, New York, 1928.

Attar of roses, the first essential oil to be obtained in a pure state, was accidentally produced in Persia about 1612. Eau de Cologne, which has been popular for more than two centuries, is said to have been first manufactured in Cologne in the early part of the eighteenth century and was sold in great quantities during the Seven Years' War for the remedial qualities it was supposed to possess.

Important among the substances used in the making of perfumes are the animal scents, or so-called "fixatives"—musk, civet, ambergris and castor—all of them obnoxious if used alone. The scent of musk, which is secured from the musk deer of Siberia, Tibet and China, is so strong that it may not be shipped in the same cargo with tea, and its value is greater than its weight in gold. Ambergris, which is even more valuable than musk, is a product secured from the sperm whale. The Oriental civet cat provides the civet that is used as a perfume ingredient, while castor is secured from the beaver. These "fixatives" are combined with the delicate flower scents and furnish the base of the perfume.

Every country and climate contribute to the supply of flowers for perfume-making. Flowers are picked at the exact moment when their scent is strongest. Roses are gathered as soon as they open, carnations after three hours' exposure to the sun, jasmine immediately after sunrise, and so on. One authority

states that white flowers give by far the largest majority of sweet odors. Yellow flowers are next, and red is a close follower. Blue, violet and green are far behind, with orange and the brownish tints last. Some flowers, such as lavender and wild thyme, lose their fragrance if transported, and therefore stills are set up in the fields where they grow.

Since distillation is not potent to extract fragrance from most flowers, the processes of maceration and inflowering are extensively used. In maceration, huge vats of melted beef or pork fat are used in which the fragrant parts of the flowers are mixed until the odor is exhausted, when they are drained off and fresh flowers added, and this process is repeated until the desired strength is attained. In inflowering, fresh flower petals are placed twice a day on plates of fat-coated glass, which are kept in air-tight compartments, sometimes for months, until the right strength is reached, when the pomade, as the fat is then called, is melted from the glass with warm water and treated with alcohol. It is then ready for the perfumer.

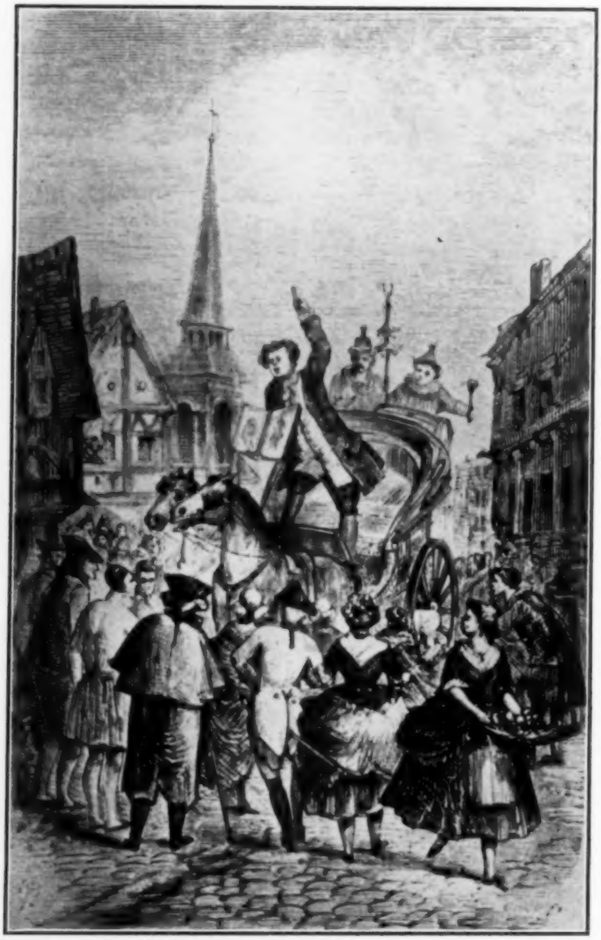
Extravagance among the ancients was not confined by any means to the scents themselves. Many were the types and designs of containers for perfumes and cosmetics in use by the luxury-loving Egyptians, Romans and Greeks. Graceful and artistic, and occasionally grotesque, are the relics that come to light on the opening of graves and as the result of archeological excavations. Little ivory and wooden toilet boxes, alabaster, onyx or glass perfume bottles, alabaster vases, ointment boxes, stone kohl jars, jars of polished hematite, serpentine and alabaster—all bear their mute testimony of the popularity of cosmetics. As many as fifty or more small, dainty phials, bottles and jars which held oils and cosmetics for the use of the dead have been found in a single tomb. Later, "pomanders" became an article of fashionable luxury. While this article doubtless was originally composed of medicinal substances as a preventive of infection, it soon developed into an exquisite article of jewelry containing favorite perfumes. The globular cases containing the pomanders were worn on a chain around the neck or as a pendant hung upon the girdle. They were made of gold or silver, and sometimes were mounted with precious stones. "The Receipt Book of John Middleton," published in 1734, gave the following recipe for a pomander:

"To make a Pomander

Take Benjamin, Labdanum and Storax of each an ounce. Then heat a mortar very hot and heat them all to a perfect paste adding four grains of Civet and six of musk. Then roll your paste into small beads, make holes in them and string them while they are hot.

Sometimes the cases were divided into several partitions, in each of which was placed a different perfume. A nutmeg, set in silver and decorated with stones and pearls, was occasionally used as a pomander, and oranges became popular pomanders soon after their introduction into England. Usually the center was hollowed out and filled with spices or other scents. When the case was of

A "PYXIDE" OR COVERED JAR FOR COSMETICS, USED BY THE GREEKS ABOUT 800 B. C.
(In the University of Pennsylvania Museum.)



A STROLLING PERFUME VENDER OF THE TIME OF LOUIS XV
(AFTER RIMMEL.)

silver it was perforated with holes, to let out the scent, and thus originated the present-day vinaigrette. "Casting bottles," containing a top or stoppers pierced with little holes, were used in Shakespeare's time for sprinkling perfume on the head, face and hands. In the seventeenth and eighteenth centuries, the laboratory of the monastery of Santa Maria Novella, of Florence, was famous for its scents which were placed in tiny bottles in small boxes or cases, sometimes resembling a book, the covers being ornamented in gold or color.

Selling methods, too, have traveled their devious ways down through the ages. The ruins of Herculaneum and Pompeii have yielded signs that appear to have been made of stone, or terra-cotta rilievo, and let into the pilasters at the side of the open shop-fronts. At a perfumer's shop, four men carrying a box with vases of perfume, and men laying out and perfuming a corpse, were shown as representative items of

that profession. In Athens, the shops of perfumers served as meeting places for all classes of society, including statesmen, artists, philosophers, and men of fashion, who discussed affairs of state, scandal and the latest fashionable intelligence. Among the Romans, as perfumes increased in popularity, the perfumers were despised. Decent people never entered their shops without hiding their faces, and rich persons had their own perfume laboratories.

In London, the selling of perfumes and cosmetics was often combined with the selling of medicines. Quackery was one of the most flourishing of occupations there in the seventeenth century. Gaudy handbills told of miraculous remedies; nurses, landladies and a retinue of followers were hired or bribed to proclaim the skill of the notorious quacks; a "Zany" or "Merry Andrew" was employed to enact the part of fool on the stage or street to attract the attention of gullible crowds; flowery oratory rendered the credulous audiences helpless before the marvelous remedies for every imaginary ill—physical or mental. A part of the speech of one Ben Willmore will sufficiently illustrate the vaunted efficacy of their wares. Dressed in a scarlet coat trimmed lavishly with braid, wearing a cocked hat with a feather, and holding aloft a small bottle, he would call from his stage on Tower-hill:

Gentlemen and Ladies,

Behold this little vial, which contains in its narrow bounds what the whole universe cannot purchase, if sold to its true value. This admirable, this miraculous Elixir, drawn from the *hearts* of *Mandrakes*, *Phoenix Livers*, *Tongues of Mermaids* and distilled by contracted *Sunbeams*, has, besides the unknown virtue of curing all distempers both of mind and body, that Divine one of animating the Heart of man to that degree, that however, remiss, cold and cowardly by Nature, he shall become *Vigorous* and *Brave*.

Gentlemen, if any of you present was at Death's Door, here's this, my *Divine Elixir*, will give you Life again.

"This will recover whole fields of Slain,
And all the Dead shall rise and fight again."

Come, gentlemen, buy this *Coward's Comfort*, Quickly buy! What fop would be abused, mimick'd and scorn'd for fear of wounds that can be so easily cur'd. Who is it, would bear the insolence and pride of domineering great men, proud officers or magistrates? What foolish heir, undone by cheating gamesters?

What Lord, would be lampooned? What poet, fear the malice of his satyrical Brother? Come, buy my Coward's Comfort, quickly buy!

Here Gent, is my little Paper of Powder whose value surmounts that of *Rocks of Diamonds* and *Hills of Gold*. 'Twas this made *Venus* a goddess and given her *Apollo*.

Come, buy it Ladies, you that would be fair and wear eternal Youth, and you in whom the amorous fire remains, when all the charms are fled; you that dress young and gay, that patch and paint, to fill up sometimes old furrows on your brows and set yourselves for conquest though in vain. Here's that, which will give you *Auburn Hair*, *White teeth*, *Red Lips* and *Dimples* on your cheeks. Come, buy it, all you that are past bewitching, and you'd have handsome, young and active Lovers!

Come, all you City wives, that would advance your husbands to be Lord Mayors, come buy of me new *Beauty*. This will give it, though now decayed as are your shop commodities; this will retrieve your customers and vend your false and out-of-fashion wares. Cheat, lye, protest and couzen as you please, a *handsome wife* makes all a lawful gain.

In spite of the inability of cosmetics to make all women beautiful, their use has grown prodigiously in recent years, and doubtless will continue to grow so long as women are women and men are men and the wherewithal is available to pay for them.

THE CULTURE OF THE CAMPAS INDIANS OF SOUTH AMERICA

By Professor MORRIS G. CALDWELL and JOHN CALHOUN
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I. Geography, Climate, Etc.

The Campas Indians are located in east central Peru. This region comprises several thousand square miles of jungle and mountainous lands. It is bounded on the east by the Ucanali River and on the west by a line extending from Jauja, through Tarma, to Huanuco. This area extends as far north as the Pachitea River and as far south as the Mantaro River. Several rivers, which are tributaries of the Amazon, form a network throughout the entire region. The climate is tropical. The rainy season lasts during our winter months. The lowlands are covered with a dense undergrowth and impassable jungle. This vast tropical region may be legitimately called the Campas Culture Area, because the culture of these Indians is uniformly characteristic of the whole district.

It is not known how many people inhabit this vast area, but it is estimated at several thousand natives. The Campas Indians are a race of small stature, averaging about five feet two inches in height. They resemble certain tribes of North American Indians in stature, physiognomy and general physical characteristics. These people all speak the Campas dialect. There are no written records of the history of these peoples, due to the absence of written language. The customs, folkways and mores of the group are passed on to the next generation by word of mouth.

II. Material Culture

Although these native Americans appear somewhat backward and retarded in non-material culture and social organization, nevertheless, they possess a well developed material culture. Some

FIG. 1. A TYPICAL GROUP OF CAMPAS INDIANS.

of the most important material culture traits may be described as follows.

Weapons: Human weapons consist of arrows made of bamboo reed three feet long by one quarter inch in diameter, with a sharpened palmwood head approximately sixteen inches long. The arrow is feathered on the tail end. The arrows used in killing large birds are made of bamboo reed four feet long by one half inch in diameter, with a hard palmwood head ten inches long. Encircling the arrow point are four small sharpened prongs three and one half inches long. These prongs pierce the body of the wounded bird and hold it fast until the hunter arrives. Both the human and game arrow heads have notches on them. This helps the arrow to stick to the flesh into which it is fired. Arrows for stunning small birds are made from bamboo reed three feet and nine inches long by one half inch in diameter with a blunt hardwood head about two inches long. The feathers of brilliantly colored birds are much in de-

FIG. 3. A TYPICAL MOTHER.

FIG. 2. NATIVE WOMAN CARRYING YUCCA.

mand for personal decoration. Arrow for deer are made from bamboo reed of usual length and thickness, with a flat bamboo head thirteen inches long by one inch in width and about a quarter of an inch thick. The head is fastened to the reed by homegrown cotton thread. The fish arrow is also made of bamboo reed, with a twenty-inch triangular palmwood head with three sets of barbs or notches on it. The bow by which the foregoing arrows are fired consists of a palmwood stick five feet long, one and a half inches wide and about one quarter of an inch thick. The bow is strung with a coarse cord made from a very tough native vine. The fish spear consists of a flat hardwood head twelve inches long. This head has a sharp point and edges. The head is fitted into the socket of a bamboo shaft six feet long and one inch in diameter. Fishing

is universally carried on from the canoes.

Hunting axe: This axe is a dull bladed instrument made of soft porous stone. The axe blade is about four inches long and four inches wide and about one inch in diameter at the thickest place. The axe head, which is a "V" shape, is set into a wooden handle two feet long and fastened there by strong cord. The axe is used as a tool and also as a weapon of war.

Due to the impassability of the jungle, water transportation on the system of rivers is the principal means of communication. Dugout canoes thirty-five feet long and five feet wide are made from the palmwood tree by means of stone axes and the use of fire. The canoe is propelled forward by means of two oars, one on each side. Each oar has a blade fifteen inches wide and three feet long and a handle three feet in length. The sides of the canoe are generally painted with designs of various kinds. Transportation is reckoned in days, so many days up the river and so many days down the river.

Pottery: Pottery jars are made of a yellow clay from the banks of the rivers in sizes ranging from one half pint to a gallon. These jars are used for carrying water, gathering berries and fruits and storing foods. They are most always decorated with dyes made from the bark and roots of a certain kind of tree. In the absence of pottery, gourds are used as containers.

Spinning, weaving and clothing: Cotton grows wild in the highlands of this region. It is picked in much the same manner as it is in the South of this country. The cotton is then spun on to a spindle, which is nine and one half inches long. On one end of the spindle is fastened a cylindrical stone one inch in diameter, which serves as a balance wheel. The spindle is operated between the palms of the hands. When the spindle is full it looks like a big spool of thread. The cotton thread is then woven on to a triangular hand loom. The loom ranges in size from ten inches wide and twenty inches long to six feet wide and eight feet long, depending on the size of the garment to be woven. All garments are then colored by a dye made from the bark of a tree. The cushma is the principal garment worn by the natives of this region. It is a sort of a "slip-over" garment. It has slits for the neck and arms, but no sleeves. A simple slit in the garment

FIG. 4. CHIEF HUSANCO.

for the neck indicates a female garment, while a "V" shape slit is for the male. These garments are often decorated with feathers and bunches of bone, seeds, nuts, toe nails of small animals, and bones of small birds and monkeys. The pancho is a top garment worn in rainy weather, also in cold weather for the Campas Indians living in the mountains. Most of the natives possess a large pouch made of cotton cloth, which is hung over one shoulder. This pouch

contains the tinder, whistles and chewing material for the day's journey.

The women are the "beasts of burden" in this region. They transport heavy materials by means of huge carrying bags or nets which hang down the back. The weight of the load is borne by a three inch band which goes over the top of the head.

Foods: The chief food of this area is the yucca. It is a tuber-like vegetable which grows underground. It is boiled and prepared for table use in the same manner as potatoes. The native also eats the heart of the cabbage palm tree, which is cooked like cabbage and resembles it in flavor. Bananas, wild oranges and limes are the principal fruits. These people balance their diet with a variety of meats, including the monkey, deer, birds, variety of fish, all kinds of insects, worms, ants and certain snakes. The Campas Indians use fire in the preparation of their food. They kindle it by means of the bow and arrow method. The leaves of the coca are preserved and carried in a hollow section of a bamboo stick. These leaves are chewed like tobacco after they have been moistened with a little powdered lime. An intoxicating beverage is made by the old women of the group who are too old to work in the yucca fields. These old women form a circle around a big gourd jar and begin chewing on the yucca root. When their mouths are full of juice, they spit into the gourd. When the gourd is full of juice, it is put aside to ferment. In due time the mould and other extraneous material is strained off and the remainder, which is pure alcohol, is consumed. A socialized good time follows. There is much dancing and beating of the drums.

Ornaments and decorations: Strings of beads, measuring four feet in length, are made from hard seeds of certain tropical bushes and vines. These seeds are about half the size of a cranberry. They are boiled in water until soft, and then threaded on to tough cords in color designs and patterns. The black and white strings of beads are worn by the chieftains, and the red and black, or pure red are worn by the women. It is worn over the head and one shoulder. Often a string of beads may have the toe nails of a sea cow or anteater tied to it for decoration. Strands of native grass are woven together into bands or loops and worn over the head and one shoulder by the women. Rouge, made from the red bark of a certain tree, is worn on the forehead, nose, cheeks and chin by all members of the group in profusion. Bunches of brilliantly colored bird feathers are worn for decoration. The corona is a head crown made of split bamboo covered in design with highly colored cotton threads. It is decorated with one or more bird feathers.

Musical instruments: The Campas Indians have four important musical instruments: the "tom-tom" drum, the bow violin, bone whistle and the pipe whistle. The "tom-tom" is a hollow section of bamboo tree ten inches long and eight inches in diameter, covered at both ends by monkey skin. The drum is beat upon by the leg bone of a deer. The bow violin is played upon by a limber reed about two feet long. The bone whistle is the leg bone of a deer with two holes drilled through it to blow on. The pipe whistle consists of five hollow reeds tied together with native cotton cord.

III. Social Organization

The social organization of the Campas Indians is very simple, indeed. Polygamy is the order of the day. There is no limitation on the number of wives a man may possess. When a man marries a second wife, he may kill his first wife if he so desires. It is not considered a criminal offense, but simply regarded as "good taste" on the

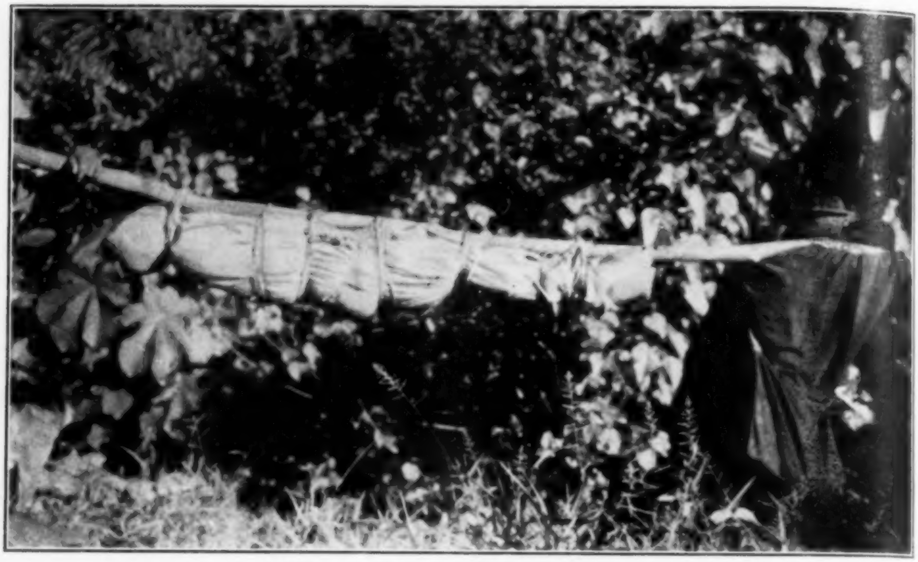

FIG. 5. A FUNERAL PARTY.

part of the male. There is no such thing as private property, outside of clothing and a few personal effects. The ownership of the land is vested in the tribe. The Campas Culture Area is not a homogeneous entity politically, but rather a multiplicity of groups, each under the leadership of a chieftain.

IV. Religion

The Campas Indians are sun worshippers. They are desolate when night comes because their god has disappeared. They practice no religious rites or ceremonies and have no medicine men. They believe in life after death, but an existence, moreover, in which the soul roams constantly through the jungle, seeking rest and finding none. The adult person at death becomes an evil spirit. If he has a house or other property it is burned immediately, so that the evil spirit can not come back to haunt the place. Fire is supposed to chase away evil spirits, so a native always starts a fire wherever he sleeps at night. The spirit of a child after death is not evil, but comes back into the home and so the mother must make provision for it. If she goes canoeing on the river, she must tie a tiny raft behind her boat for the child's spirit to ride in. If the mother goes into the forest and finds a large fallen tree, a stick must be laid against each side of the tree for the spirit of the child to cross over.

When a member of the group dies, the corpse is wrapped in cotton cloth from head to foot and tied to a long pole for convenience in carrying to the funeral. The manner in which the dead are disposed of is not known. The natives are determined to keep this a secret of their race. Any white man who attempts to pry into this mystery is endangering his own life. The accompanying picture is a snapshot of a funeral party proceeding through the jungle, taken without the knowledge of the natives.

SINO-AMERICAN POINTS OF CONTACT

By Dr. BERTHOLD LAUFER

CURATOR OF ANTHROPOLOGY, FIELD MUSEUM OF NATURAL HISTORY, CHICAGO

ABOUT a hundred and fifty years ago Americans first came in direct contact with Chinese when the American ship *Empress of China,* sailing from Boston and rounding the Cape of Good Hope, cast anchor in the harbor of Canton. This occurred in the year 1784, under the reign of the great Emperor Ch'ien Lung, who was a contemporary of George Washington. Thus Americans were late arrivals—in fact, the last of foreign peoples to enter into commercial and political relations with China. Europeans, first the Portuguese, then the Spaniards, Hollanders, British, and French, had preceded them by several centuries. It is no empty saying that from the first days of Sino-American intercourse the two great countries have been linked by bonds of sympathy which have not existed and do not exist between China and any European power. These bonds of sympathy and friendship have been strengthened from year to year, as witnessed particularly by the ever-increasing number of Chinese students and scholars annually flocking to our universities athirst for knowledge.

What, then, have Americans and Chinese in common? I think, a goodly number of very fine traits. First, the spirit of democracy, which has pervaded China for more than two thousand years, ever since the First Emperor Ch'in Shi smashed the old feudal system. The principle of government for the benefit of the people certainly is American, but it is equally Chinese and goes back to the fourth century B.C., when Meng-tse (Mencius), the most gifted of Confucius's disciples proclaimed the doctrine, "The people are the most important in a nation, and the sovereign is the least important of all." Second, the spirit of religious tolerance. I know of no more tolerant nation than the Chinese. Third, the lack of a caste system and lack of a hereditary nobility. China was always guided and governed by an aristocracy of intellect, not of birth; the old system of free competition by civil service examinations recruited the best talent from all ranks of society. Fourth, Americans and Chinese do not suffer from the obsession of that great evil, the race superiority complex; they are averse to armed force; they are friends of peace, and are animated by a deep sense of justice and fair play toward all, regardless of race, color or creed. Fifth, and this is the greatest asset that the two nations have in common, they have an unbounded, almost religiously fanatic, faith in the power of education and knowledge as the best guarantors of progress, as the best possible safeguards of the permanence of their social structure and institutions. With this capital of a common historical tradition and mentality—democracy, tolerance, equality, justice and education—we are well prepared to stand the test and storms of the time.

Aside from these ideals, there are culture elements inherent in the two civilizations that establish a common basis for a harmonious social life and sympathetic fellowship among representatives of the two nations. In reflecting on cultural similarities between Americans and Chinese, it is advisable to proceed from realities and direct observations. A white man who is in a good state of health is able to live in China in a house of Chinese style, in a purely Chinese surrounding, on Chinese food,

in every fashion exactly like a Chinaman, not only for years, but a lifetime, without suffering impairment or injury to his health. Chinese houses are very much like our own; their plan of arrangement comes very close to that of the ancient Roman house. Rooms are airy, spacious and well-ventilated, and comfortably stocked with tables, chairs, armchairs, settles and sofas. There is no other nation in the world whose house furniture offers so complete and striking a coincidence with our own. In fact, it is one of the amazing points of culture history that of all nations of Asia the Chinese is the only one that takes its meals seated on chairs around a table, in the same manner as we do. This custom was acquired by the Chinese only in comparatively late historical times. The ancient Chinese, down to the epoch of the two Han dynasties, used to squat at meal times on mats spread over the ground, in the same way as it is still customary with the Japanese and the peoples of India. The remarkable step leading to the use of raised chairs and high tables was taken in the period between the Han and T'ang dynasties, as a sequel of many foreign influences that came from Central Asia at that time, and speaks volumes in favor of Chinese adaptability and readiness to adopt foreign institutions. The Japanese, with all their temperamental changeability, still adhere to the old primitive custom of sitting cross-legged on the mats covering the floors of their rooms; and while an American, for curiosity's or experience sake, may enjoy living in a Japanese home for a few days or weeks, he will never acquire the Japanese mode of sitting, which is a source of physical discomfort to us.

The objection may be interposed that many travelers and adventurers in almost all parts of the world have conformed to the life of the natives whom they set out to explore. Such examples indeed are numerous. Any normal individual of good physique and temperate habits is able to live wherever other human beings of whatever race can exist, whether they be Eskimo, American Indians, South Sea Islanders, Pygmies or Negroes, Berbers or Beduins; but such adventures are usually transient, and the explorer will always be glad, once his task is accomplished, to return into the harbor of "civilization." Speaking of myself, it fell to my lot to live for many months among such primitive folks as the Gilyak and Ainu of Saghalin Island, the Golde and Tungusian tribes of the Amur region, sharing their huts or spending the night in the open, sleeping on a bearskin, living like them on salmon and game, even amid smallpox and trachoma epidemics, without any harm to my health, save a temporary discomfort from parasitic insects. I could not, however, have stood this sort of life for a number of years, and while I enjoyed studying these tribes and gathering data concerning their daily life, languages, folk-lore and religion, I can not say that I felt at home with them, at least not so intimately as I do feel at home with the Chinese. It was also my good fortune to spend a year and a half among the Tibetans, both the nomads and the agriculturists, just living like one of them; and while the Tibetans have my unstinted sympathy, the time I should be willing to dwell in their midst will always be one of restricted duration. The lesson to be retained, therefore, is that a robust man with a definite object in mind may live anywhere without hazard of life and welfare within a limited period, whereas no such time limit is attached for us to China. Again, it can not be doubted that many white individuals have settled among Indians, Eskimo and other primitive peoples, taking native women as their wives, even adopting native speech, clothing and habits, and thus ending their days. Examples of this kind are not typical, however, and such indi-

viduals have usually been fugitives, castaways, tramps, derelicts or sailors cast adrift.

In order to settle among the Chinese, no foreigner need feel anxiety about his health, at least no more than if he stayed at home, nor does he require the explorer's physical fiber. China beckons to the man of culture, and the more cultured he is, the more welcome and the happier he will be there, since the Chinese are highly cultured, well-bred and well-mannered people. Even most Chinese farmers and laborers are gentlemen, and from many of them many a so-called gentleman in our midst could learn many a useful lesson in good manners or etiquette.

One of the most remarkable inventions ever made by the Chinese is the chopsticks, "the nimble ones," as they are called in Chinese, the invention of which goes back to the days of the Chou dynasty. Chopsticks are not only characteristically Chinese but also set the Chinese people clearly off from other nations of Asia that are still in the habit of taking food to their mouth with their fingers, which is even done by so highly civilized people as those of India. Annamese, Koreans, Japanese and other peoples who came under the spell of Chinese civilization adopted from the latter the use of chopsticks. It is self-evident that these make for good table-manners, which are the first criterion of a civilized individual; and whatever opinions we may hold on the Confucian system of ethics, it is undeniable that it has at least brought about the one good effect to transform the majority of the people into a body of highly decent, respectable and well-bred men. The sanctity of the home and the purity of family life belong to the greatest achievements of Confucian social ethics. For all these reasons, official and personal intercourse of Americans with Chinese is easy and a source of pleasure. Their sense of humor, their delight in story-telling, their conversational gifts and oratorical power are other qualities that will not fail to make a strong appeal and endear them to us the closer we get acquainted. At Chinese parties there is less formality and conventionality than in our country.

Their eminent faculty of assimilating and absorbing foreign racial elements has struck many observers. In fact, the Chinese no more than any other nation represent a pure race. The northern Chinese have a strong admixture of Tungusian, Mongol and Turkish blood; the southerners have to a great extent intermarried with the aboriginal tribes which preceded the Chinese as owners of the country. The question of intermarriages of Chinese and whites is naturally a delicate one, and it would be futile to generalize on so vital and large a problem; but if limited personal experience and observation may count a little, I may say that many happy marriages of Europeans and Americans with Chinese women have come within my notice. There is no gulf separating the two races, and there are no obstacles of a racial or cultural character in the way of such unions. The offspring of American fathers and Chinese mothers belongs to the best citizenry of China, and commanding the two languages as they do, they make the best liaison officers to maintain and strengthen the bonds between East and West. Many of these Eurasians are splendid fellows, and I have found in them the most willing and enthusiastic helpmates in scientific investigations.

As an analyst of human nature I should be the last to deny that there are psychological differences between Chinese and ourselves. These, however, do not spring from a basically divergent mentality or psyche but are merely the upshot of a distinct set of traditions and education based upon the latter. As the grasp of ancient traditions upon their minds will gradually loosen and as the best in our institutions and inventions

will be adopted (I advisedly shun the ambiguous and much misused word "progress"), these small divergences will gradually disappear or be reduced to a minimum. The abandonment of foot-binding and opium-smoking may be cited as relevant instances. The student of anthropology who has learned to fathom and to understand the customs and usages of every people knows only too well that the Chinese are not different from other peoples but are just human and humane. There is no custom in China that in one or another form would not appear among other peoples or even among ourselves. The Chinese worshiped their ancestors and to a large extent still do so; they are justly proud of their ancestors, and in their modesty attribute their own good luck and success to their ancestors' virtues and beneficent influence. We, with our pride in ancestors and with our passion for genealogical quests, are no less ancestor worshipers; our "worship" has merely assumed a different form.

The following simple story will illustrate this point and is also instructive in teaching that East and West, with a little good-will and thoughtfulness, are able to understand each other. An American sailor and a Chinese youth met at a cemetery near Shanghai. The sailor carried a wreath of flowers, ready to place it on the grave of a comrade who had perished in a typhoon in the China Sea. The Chinese boy carried a bowl of rice with a pair of chopsticks laid across it. The two engaged in a confabulation, and the sailor remarked laughingly, "John, what is the big idea of taking a bowl of rice to a cemetery?" And John replied, "I am going to put this bowl of rice on the grave of my ancestors as an offering to them." "Good work!" retorted the American, "And do you really believe that your ancestor will descend from heaven to eat your rice?" And John came back with this repartee, "Sure, if your ancestor can come down to smell your flowers, mine may come down as well to eat my rice!"

WILL BIRTH CONTROL LEAD TO EXTINCTION?

By Professor S. J. HOLMES

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ANY one who has had much contact with the active partisans of the birth control movement can not fail to be impressed with their intelligence, moral courage and sincere concern for the welfare of humanity. The movement is championed by teachers, writers, social workers, ministers, even bishops and reverend deans—all sorts of aggressively good people who are firmly convinced that birth control will afford a potent remedy for many of our worst social and economic ills. One feels almost guilty in saying anything calculated to dampen the ardor of these zealous humanitarians. But, being possessed of a scientific conscience, I can not refrain from making some comments on a possible effect of birth control which, obvious though the possibility is, has seldom received adequate consideration. If a remedy relieves the patient only to kill him off later unless it is wisely employed, we should obviously pay some heed to the avoidance of its dangers.

That the practice of birth control would confer an inestimable boon upon many ailing and overburdened mothers admits of no doubt. That it would bring the means of securing a higher standard of welfare to the peoples of such grossly overpopulated countries as China, India and Japan is equally obvious. On the other hand, birth control is largely responsible for the very low birth rate of the more intelligent and educated classes of both Europe and America. In several countries at least, the people whose position or achievements indicate that they possess a superior inheritance of brains are not producing a sufficient number of children to perpetuate their stock. Whatever its benefits may have been, birth control must bear the responsibility for the evils of the differential birth rate which have aroused the doleful lamentations of the eugenists.

That the race is at present tending to breed out its brains is possibly only a temporary evil which may be remedied by encouraging birth control in the lower hereditary classes. One of the favorite arguments of the advocates of birth control is that the reduction of the birth rate among people of inferior heredity affords the most feasible method of eugenic reform. There can be no doubt that the quality of the race would be improved if fewer children were produced by the masses of stupid people who are now most given to unrestrained fecundity. And there is probably something in the contention that the reduction of the birth rate in this class would automatically bring about a more rapid multiplication of better endowed individuals.

In bringing the propagation of human beings under voluntary control we should be alive to the dangers as well as the possible benefits of this change. Few people realize the momentous possibilities both for good and for evil which this change involves. The decline in the birth rate, which is to a large extent due to birth control, has already been fraught with tremendous consequences to the population growth of both Europe and America. At times, and in some countries, the death rate has fallen more rapidly than the birth rate, so that the net rate of population growth has not fallen off, but this condition is far from typical. Obviously the death rate can not fall indefinitely, while the birth rate can. The death rate will decline more slowly as people come to approach the maximum natural span of life. Rates of increase have for some time been growing slower. Year after year the vital

statistics of most civilized countries record a lower birth rate than ever before. Since the great war the decline has continued at an accelerated pace. Will the birth rate continue to fall? There seems to be every indication that it will. In fact, several countries of Europe are threatened with an actual loss of numbers in the not distant future. For some time France has maintained a nearly stationary population only through the immigration of relatively prolific aliens from beyond her borders. The latest report from Germany (1928) gives a birth rate of only 18.6 per 1,000, a figure lower than the birth rate which has long prevailed in France.

One circumstance which has prevented us from realizing how nearly inadequate are the birth rates prevailing in many countries is that the age composition of the inhabitants is especially favorable for a high birth rate and a low death rate. Where the birth rate has been falling the proportion of children is relatively low and the proportion of people in the reproductive period of life is apt to be large. A small number of infants and very young children in a population tends also to reduce the general death rate. A population which includes a high percentage of people of adolescent and middle age may show many more births than deaths, while at the same time the reproductive rate is not high enough to secure its continued propagation. In time a population tends to outgrow the anomalies of its age composition. Because births outnumber deaths it does not follow that a population will go on increasing.

This fact, which has generally been overlooked even by specialists in vital statistics, has been brought out very clearly in a recent book by Kuczynski on "The Balance of Births and Deaths." Kuczynski has studied the stabilized rates of increase of the countries of Northern and Western Europe and finds that, were it not for their peculiarly favorable age composition, the peoples of most of these countries would be actually diminishing in numbers. At the birth and death rates prevailing from 1922 to 1925 in France 1000 women would produce only 937 women who would live long enough to replace them. Measured in the same way the reproductive rate of England in 1927 was about 910. In the same year Germany had a reproductive rate of only 830—which will be good news to the French. The stabilized rate of natural increase in the birth registration area of the United States was estimated by Dublin and Lotka to have been only about 5.5 per 1,000 in 1920, and a more recent study by the same writers has shown that by 1928 it had fallen as low as 1.7 per 1,000. Even with no further changes in the fertility or mortality of different age groups the population of the United States would gradually settle down to a nearly stationary condition.

These striking revelations of recent students of vital statistics indicate that, in the near future at least, the specter of overpopulation need not alarm us. Some of the overcrowded countries of Europe might well spare a few millions of their inhabitants and be all the better for the loss. Were it possible to do so, it would be desirable to keep the population of every country at that level which is most conducive to the welfare of the people as a whole. Some countries have altogether too many people for their own good, and others perhaps have too few. That the decline of the birth rate will be halted somewhere near the population optimum can not be assumed. To what lengths the reduction of the birth rate may go until, if ever, it comes to a natural stopping place we have at present no means of knowing. It is true that populations in the past have been subject to a sort of automatic self-regulation of numbers. Among human beings, as among the lower animals, the reproductive instincts could always be relied

upon to furnish a birth supply more than adequate to perpetuate the species. However the ranks of humanity might be decimated through war, pestilence or famine, human fecundity has always proven sufficient to make good the losses. Population has been compared with an elastic spring ever ready to expand upon the release of pressure. But whether this self-regulation of numbers would occur in a people among whom procreation had come to be an entirely free will offering to posterity is open to some doubt.

Let us imagine a country whose people have all become acquainted with easy and effective methods of checking the birth supply. Let us suppose that the high standards of living in this country are insured by the restriction of immigration. How far, under the circumstances, would the population in such a country tend to decrease? Are there counteracting forces powerful enough at any point to change a decrease in numbers into an increase? It may be admitted that compensating factors exist, but have we sufficient assurance that they will be able to stay the continued decrease in numbers? Can we rely upon the desire for children either for their own sake or as an economic asset later in life, considerations of race welfare, or any other motive as affording incentives which will cause the rank and file of human beings to undergo the sacrifices required for perpetuating the race? Here is the true riddle of the sphinx, for the fate of the race depends upon its proper answer.

If the sexual propensities can be easily dissociated at will from their connection with reproduction the chief factor which causes population to increase after it has sustained a loss will no longer be operative. The danger of birth control is that it strikes at the root of Nature's method of regulating numbers. Possibly other factors which induce people to have children may still suffice, but if one can believe it in the light of recent developments he must indeed be an optimist.

The parental instincts of many people are as well satisfied by one or two children as by half a dozen. There are not a few married couples who prefer to have none. It may be very desirable to have children born only when they are wanted, but one can not help wondering what under these conditions might happen to the human species. The habit of counting the cost will doubtless grow as there comes to be an increased realization that, in our modern life, rearing children involves many sacrifices for people of moderate incomes. Where the pinch of poverty is more acutely felt, people will be only too willing to avoid these sacrifices in the effort to maintain a decent standard of living.

One may be reasonably sure that the birth rate will continue to fall as knowledge of preventive methods becomes more widely diffused among the lower social classes. In Europe there has been a strong movement in this direction since the great war. In several districts of Stockholm and in some parts of Germany this extension has proceeded so far as practically to obliterate the differences in fecundity between the upper and the lower social strata. Knowledge of contraceptive methods is bound to increase, and it is futile to attempt to check it by adverse legislation. In most countries the rank and file of the population, especially in rural districts, are still in an unsophisticated stage. Any one who reads the harrowing letters in such books as Mrs. Sanger's "Motherhood in Bondage" or Mrs. Stopes' "The First Hundred Thousand" will realize the extent of popular ignorance on this subject, and the eagerness with which knowledge is sought. An interesting picture of the situation is portrayed in the Lynds' book entitled "Middletown." In discussing the attitudes toward voluntary parenthood the authors state that "all of the 27 women

of the business class who gave information on this point used or believed in the use of some form of birth control, and took it for granted. Of the 75 wives of workers from whom information was secured on this subject only 34 said that they used any means of birth control; of these 12 were "careful," 2 used primitive practices, and only 20 used artificial means that might be considered moderately scientific. Of the 34 not using any means of birth control 15 vaguely approved, 15 definitely disapproved, 4 were ignorant of all contraceptives except such as their husbands were unwilling to use, and 9 were eager for some means of control but totally ignorant of any."

This picture is probably as typical of the ignorance and confusion among the working classes as Middletown is typical of a mid-western town. To judge from the number of babies in this town who were not wanted, at least before they arrived, a wider diffusion of contraceptive knowledge would depress the general birth rate to a considerably lower level.

Another factor to be reckoned with is improvements in technique. Most of the contraceptive methods now employed are by no means infallible and suffer from drawbacks which prevent their use by the poorer inhabitants of overcrowded quarters. There is a stratum of ignorant and shiftless poor who apparently care little whether babies come or not. On the other hand, there are countless overburdened mothers who would gladly employ any safe and effective means of contraception within their reach. Should experimentation result, as it promises to do, in the discovery of more effective methods adapted for employment under the most unfavorable conditions of life it might eventually lead to a marked reduction in the fecundity of a large class which is now little affected by the birth control movement.

It is a significant fact that those countries, in which the decline of the birth rate has filtered down to the proletariat, not only have a very low general birth rate, but owe their present surplus of births over deaths largely to the favorable age composition of their inhabitants. For some of these countries an actual loss of population would confer an immediate benefit. The economic advantages resulting from this loss would naturally have the effect of enticing immigrants from surrounding areas. These countries may succeed in protecting their standards by the exclusion of immigrants, but the ability to do this implies the strength necessary to enforce their restrictions. Thinly populated Australia without the protection of Great Britain might not be suffered to remain a white man's country in face of the teeming millions of Asia who are seeking room for expansion. A weak country can succeed in keeping its territory for its own people only through the protective arm of other countries. If the protectors should become afflicted by the same weakness the position of all of them becomes insecure.

Without presuming to forecast the future, one may point out the possibility that the reduction of the birth rate in the nations under Western civilization may fall so low as to cause them to lose their supremacy in world affairs and to be invaded by peoples from other parts of the globe. The more immediate danger to the nations of Northern and Western Europe, however, lies not in forcible invasion, but in a peaceful influx of immigrants who will be welcomed as laborers. In many of the northern and eastern parts of the United States the older American stock is dying out and is being replaced by immigrant peoples who were wanted for their cheap labor. The process of replacement may or may not be harmful depending upon the inherent worth and civilization of the incoming stocks. The ancient Greeks and Romans drew in alien peoples, reduced their own birth rate, and disap-

peared. The extent to which birth control has been responsible for the extinction of the stocks which have built up great empires in the past can only be surmised. The practice was certainly prevalent enough in ancient times; but for the lack of adequate documents its history as a cause of extinction will probably never be written. As to its future functioning in world history we shall doubtless have abundant information.

One of the greatest problems facing civilized mankind is how to secure the undeniable economic, humanitarian and eugenic benefits of birth control and at the same time escape from its very real dangers. In taking over the regulation of the birth supply humanity has assumed a very great responsibility. One meets with little manifestation of concern over this responsibility in the typical birth control propaganda of the day. We are seldom reminded that the misuse of birth control has done a tremendous amount of damage and promises to do much more. The birth control movement arose out of the desire to relieve the overburdened mothers among the wage earning classes, and it is still motivated largely by the humanitarian aims of its early protagonists. These are worthy aims, but there is great need for the spread of enlightenment upon the larger aspects of the subject. The problems created by the growing practice of birth control are far more serious than is commonly realized. They will not be solved by the easy method of *laissez faire*, nor by fulminations against the wickedness of contraception. They may prove too much for us to cope with, and then Nature will deal with us as she does with species which fail to adjust themselves to changed conditions of life.

SOCIAL PSYCHOLOGY AND SOCIAL REFORM

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Social Science and the Doctrine of Progress

The wish to improve or reform social conditions seems deeply ingrained in Anglo-American culture. The theory of life to which we are exposed early and late is one of material progress and continuous moral improvement. The Christian religion with its doctrine of salvation, the modern applied natural science with its omnipresent effects upon our material culture, and the dogma of consciously controlled social progress have profoundly affected us. It is almost inevitable for people to ask, "What is to be done about our social ills?" If the teacher or writer merely answers, "I do not know," or worse still, confesses no interest in reform, he is pretty sure to be put down, at least secretly, either as a knave or a fool.

Social science is not unlike natural science in its efforts to attain objectivity. It essays to be as impersonal and rational as possible in treating its data. It aims above all else to neglect none of the factors, although in social phenomena these factors are overwhelmingly complex. Social psychology is in a peculiarly difficult position. It touches all the social sciences in its effort to throw light on the behavior mechanisms of people in the various dimensions of group life. It has close bearing on the special social sciences,—history, economics, politics, sociology and anthropology.

Among the methods of science every one recognizes two levels of work: first, what may be called field description or observation, and secondly, experimentation. Where the data can successfully be stripped of interfering concrete realities, as in physics and chemistry, and to some extent in biology, laboratory experimentation, with its careful and verifiable controls, may be carried on. In the social sciences, and we include much of psychology here, the data are so complex that for the present we are compelled to use description and observation. So far as the historical dimensions of the social data are concerned, we are confined largely to qualitative descriptions and the best possible use of careful observation. In much of our work, however, considerable improvement in technique has resulted from the application of the statistics of probability in analyzing personal and group behavior.[1] Actually the social sciences, including social psychology, are in the early stages of the description and observation of their data. As all science aims to eventuate in generalizations, called hypotheses and laws, so the social sciences hope ultimately to arrive at some generalizations from their data. The natural sciences are far in advance of the social sciences in this respect although recent developments have put a new cast to their generalizations once thought more or less fixed and final.[2] One of the principal handicaps in the social sciences has been their inability to free themselves from what Comte called the metaphysical stage of development. Up

[1] *Cf.* K. Young, "Measurement of Social and Personal Traits," *Publications of American Sociological Society*, 1927, Vol. XXI, pp. 92–105, (also found in *Journal of Abnormal and Social Psychology*, 1928, Vol. xx, pp. 420–42) for a discussion of the problems of historical and statistical treatment of certain socio-psychological data. See also W. I. and D. S. Thomas, "The Child in America," 1929, chap. xiii; C. O. Lundberg, "Social Research," 1929; S. A. Rice (editor) "Methods in Social Science," 1930; and S. A. Rice (editor) "Statistics in Social Studies," 1930.

[2] Note the development in physics of theories of relativity and quanta.

to the present, most, if not all, generalizations, which have been made in most social sciences, rest upon philosophical deductions and rationalizations of contemporary cultures rather than upon descriptions and observation, to say nothing of experimentation.

Because of this lack of satisfactory generalization, if no other, the cautious social scientist refrains from offering advice on "What to do" about personal and social matters. He is more interested in the development of techniques for description, observation and, if possible, experimentation, than he is in offering gratuitous and usually fallacious programs for the improvement of social life. At least he aims to be open-mindedly cautious about any practical changes made in the name of his science.

Social science like natural science is aware of the fact that sooner or later it owes a debt to the society and its culture which makes the scientific examination of its data possible. Yet, due to this inveterate craze to alter matters overnight, some people are impatient with those who refuse to rush into the public forum with proposals to improve our social living.

To the writer, the very insistence on programs from anxious folks in our society is but a phenomenon to be examined and analyzed. It is frequently forgotten that this urge to improve the world is a part of our culture and that it is only to be understood and handled as such. There are two aspects of this which should be discussed briefly. One is the doctrine of progress and the other is the doctrine of good and evil.

Formerly many men thought that society was going down hill. Others imagined it was advancing. The doctrine of progress itself has a cultural history. The notion of evolutionary stages in history was current among certain early Greek thinkers. There is something of the idea of progress in St. Augustine's philosophy of history. Yet, it was in modern times, following upon the heels of commercial expansion and material invention, that the doctrine of progress got its firmest footing. In the eighteenth and early nineteenth centuries the theory of progressive social evolution became deeply rooted in Western culture. Even under the shadow of the guillotine Condorcet expressed an all-absorbing belief in progress:

> The result of my work will be to show by reasoning and by facts that there is no limit set to the perfecting of the powers of man; that human perfectibility is in reality indefinite; that the progress of this perfectibility, henceforth independent of any power that might wish to stop it, has no other limit than the duration of the globe upon which nature has placed us. . . . What a picture of the human race, freed from its chains, removed from the empire of chance as from that of the enemies of its progress, and advancing with a firm and sure step on the pathway of truth, of virtue, and of happiness![3]

Similar notions persist down to the present. Any one who is critical of such ideas is dubbed a pessimist. Witness our calling W. R. Inge the "gloomy dean."

For the social psychologist it is interesting to discover whether the idea of progress may actually come to influence the investigations and reforms made by men in contemporary society. Optimism for the future is quite as dependent on economic and political forces as on any ideology, so that whether this idea can overcome possible inevitable limitations to social change is open to doubt. The principal difficulty with the whole notion of progress is to find any objective criterion of progress. In terms of increasing complexity of material culture it is easy to measure change. Whether this shall be called "progress" is another matter. Does progress refer to moral improvements, to such vague and uncertain criteria as "human happiness"? Or does it concern only material change? And does

[3] Quoted in K. Young's "Social Psychology," 1930, p. 448.

our material culture mean "progress" when we witness contemporary economic maladjustments between production and the distribution of wealth? To just what items in our lives does it apply? Is progress to be measured in terms of collective organization as Professor Ellwood imagines and as the Russian communists attempt to put into effect, or in terms of increased individual liberty as Bertrand Russell proposes? Is a kind of hedonistic selection to be the basis of our progress, or a severe moral organization of society welded together for some collective aim? All such questioning throws us at once into the second aspect of this matter of reform, namely, the problem of good and evil.

Born of ancient Persian or possibly older origin, the doctrine of two rival forces in the world, light and darkness, good and evil, has come down to us, largely through Christian ideology. Man is seen as ever struggling with the evil forces about him. His salvation lies in reducing the evil in the world to a minimum or, better still, completely annihilating it by the domination of good. Anciently, and even to-day in many quarters, the whole struggle of good and evil is personified in terms of a personal god and a personal devil, each aided by a host of angelic hosts, some good, the others bad. This demonology was rampant down to the age of science. It even now persists in the masses to an amazing degree. To-day, however, the followers of science conceive the problem of good and evil, not in terms of personal devils or angels, but in terms of material, biological and social forces. The handicaps due to climatic change, the disasters of bacterial infection in man and domesticated animals, the effects of poverty, prostitution and war, —these are illustrations of the contemporary evils. Over against them we put such good services as meteorological prediction, medical research eliminating malaria, typhoid, tuberculosis and other diseases, and legislative reforms concerning minimum wages, hours of work, punishment for white slavery and the fixing of international agreements to prevent war. But the problem is still phrased in a contrast to dual forces at work, one against the other.

To secure the good and to put down evil is considered progress. To lengthen the span of life, to eliminate disease, to abolish war—all these are evidences of this advancement. It follows from this that there is an anxious looking to science, as formerly there was to religion and magic, for some solution to the remaining social problems. Thus, the social psychologist is asked for his contribution to the question of how to improve the intelligence of the voter, how to allay prejudice, how to prevent mob action, how to offset the bad effects of propaganda, and how to improve the quality of social leadership. Often there is a pressing demand for such panaceas before we have the slightest objective knowledge of the matter in hand.

Because of the recency with which social psychology has come into the field, it is imperative for its ultimate service to humanity, not to demand of it pat formulae for making the world better. Only when it has accumulated a sufficient body of facts may we begin to make generalizations and lay out hypotheses or attempt to frame tentative laws. The writer sees nothing immediately ahead which encourages him to believe that this stage of the science will be reached for a long time. In the meantime, the description, observation and tentative analysis of conditions is about the best we can offer. Let him who wishes make what he will of the situation. This raises the legitimate query as to the relation of science to the technique of improvement or control. Some attention to this problem may make it clearer why the scientist is not necessarily himself concerned with offering measures of reform.

Science is concerned with objective, impersonal description, observation and experimentation. It is essentially analytical. It is interested in cutting out certain facts, in terms of its premises, from the total reality. Science is necessarily a closed system within the confines of its own premises and conclusions. Given certain fundamental standpoints and methods, science can never rise higher than these sources. Eddington puts it thus in the closing lines of his book, *Space, Time and Gravitation:*

> We have found that where science has progressed the farthest, the mind has but regained from nature that which the mind has put into nature. We have found a strange footprint on the shores of the unknown. We have devised profound theories, one after another, to account for its origin. At last, we have succeeded in reconstructing the creature that made the footprint. And lo! it is our own.[4]

Science is always to be considered from its own particular frame of reference. There are many people who fail to recognize this. They expect science to answer questions it never intended to answer. Science is not concerned with WHY but only with HOW and WHAT. The WHY may be left to another branch of knowledge, religious philosophy. Although the premises of science may relate themselves to a particular metaphysics, the essential matter of science is to discover how and what the universe is and does.

When it comes to the matter of putting science to work, we enter the dimension of techniques. In a way, we go over to art, for technology and art are closely related. Art, properly speaking, is frequently a form of fantasy engineering or an extension of our world into the realms of imagination. Technology and art both use the principles and materials of science. The bridge builder draws from physics, chemistry and mathematics. He also may have occasion to employ the principles of psychology in handling his men and the matter of economics in estimating costs of production. Thus, the engineer derives his principles and materials from various fields and weaves them together into formulae for practical use. It is not different with the social engineer, to use a somewhat outworn term. He may draw his principles and materials from biochemistry, from political science, economics, sociology and psychology in developing a health program, a new housing project, or a scheme for the care of neurotic children. All of these special fields contribute something from their sciences, which were developed without specific reference to this or that particular social invention or device. Out of this matrix, the social engineer or artist creates his new plan or project.

Art, then, in the sense of social technology, is not altogether unlike art in the narrow sense of the "fine arts"—literature, sculpture, painting and music. Art is fundamentally synthetic and creative. In this it is unlike science, which is analytical and objective. Art is, in a way, more akin to certain aspects of philosophy than it is to science.[5]

The significant thing to recall is that social engineering or applied social science is a creation from elements of science and common sense, in reference to particular situations. In contrast, science proper must rest upon analysis. It has in its method no reference to the practical application. The following quotation from W. I. Thomas is in point:

> The examples of physical science and material technique should have shown long ago

[4] A. S. Eddington, "Space, Time and Gravitation," 1920, p. 218. *Cf.* F. Znaniecki, "Cultural Reality," 1919, for a profound analysis of the whole problem of science, especially social science, in relation to the culture out of which it springs.

[5] Unless, of course, we consider science in the sense of the philosophical integration of its principles, when even science stretches beyond the laboratory and arises out of man's reformulation of his facts into theories.

that only a scientific investigation, which is quite free from any dependence on practice, can become practically useful in its applications. Of course, this does not mean that the scientists should not select for investigation problems whose solution has actual practical importance; the sociologist may study crime or war as a chemist studies dye-stuffs. But from the method of the study itself all practical considerations must be excluded if we want the results to be valid.[6]

One factor remains to be considered in discussing the relation of social science to social reform. In the field of social change, social ethics always intrudes itself. In fact, social values, with which ethics is concerned, are a part of the data of social science. Certainly the value factor in behavior must be considered in social psychology. It is one thing to consider social value as the object of study in analyzing a behavior situation and quite another matter to consider social values themselves, in relation to consciously planned social reforms. In dealing with those phases of conduct of the person which touch the mores especially, it is necessary to consider value meanings. Yet we must not confuse the efforts made by willing social scientists to offer their own interpretations and values as to what to do, with the more objective treatment of values as merely a part of social data. A good deal of earlier social science and social psychology often confused ethics and science. By this we have merely delayed the more necessary fundamental description and observation of our data and the gradual formulation of hypotheses or tentative laws, without reference to this or that particular social program.

When the matter of social ethics is introduced, one is confronted at once with the ancient query: What is the Good? What values are Right? Whatever is good or right is to be considered relative to the whole culture at the time. Too frequently social scientists have discussed institutions and social practices from the angle of their own moral code, with the result that they have made most fallacious judgments and conclusions about these matters in regard to their own and other cultures. So far as our own good and right are concerned, especially in the matter of future change, it is the business of the social engineer and the community to bear in mind this relativity of values. It is doubtful if a new *good* or *right* can cut across historical values. Thus, change, however we may conceive it, relates to historical antecedents. Even the changes in revolution and in rapidly moving times like the present, when industrial and commercial inventions have so wrought upon the face of social reality, can not escape the influences of the past. The social psychologist, then, utters at least a caution to the social engineer. The latter must not forget in formulating his projects and his values that these, to be effective, must have some vital and fundamental connection with the social-cultural past out of which they arise. Many a good reform has blossomed but to die in the withering sun of social realism. It was knowledge of this fact that led State Senator Plunkett, of New York, to utter his famous remark: "Reformers are Morning Glories." Unless reforms have within them the germs of growth in relation to what is already around them, they will never succeed. Social engineering, like all good art, is only possible in reference to the personal-social and cultural matrix out of which it arises.

Social Psychology and Social Behavior

Social psychology, as a scientific discipline, is in its earliest stages of development. It deals fundamentally with the personality in its social-cultural setting, that is, with the personality as it

[6] W. I. Thomas and F. Znaniecki, "The Polish Peasant in Europe and America" (2nd edition), 1927, Vol, i, p. 7.

is affected by other persons and as it, in turn, affects them. Moreover, these inter-effects must take into account two aspects: environment and organism. It is clear that it is through other personalities and their works that the person is developed.[7] These influences, at least for descriptive and observational purposes, may be divided into two major categories. One of these, for want of a better term, we call personal-social influence, defining this to mean the person-to-person relationship which was not standardized or conventionalized into cultural patterns. These are the influences that develop around physical differences in size of persons, strong and weak, old and young, adult and infant. They develop out of dispositional differences, dependent upon divergences in intelligence and emotions. The second set of influences are those which grow out of cultural norms: the folkways and mores, the customs, traditions, conventions of the social groups to which we belong. Some of these relate to narrow groups, like family standards of wealth, others to the community, as in dress, manners, or morals; and still others to secondary or special interest groups, such as trade unions, employers' associations, religious sects, political parties, criminalistic gangs, and so on.[8]

In actual living, these two influences are constantly intermixing with each other, but for purposes of study it seems well to distinguish between them. Out of personal-social influences of person on persons, cultural norms are constantly being fashioned. The matter is nicely illustrated in fashion and in public opinion, especially in this day of propaganda. It is also true in the development of the moral codes. Some person or small group of persons may experience a crisis. When they solve it in some particular way they may set out consciously or unconsciously to project their solution, that is, their definition of the crisis or situation, upon the larger group or groups to which they belong, be it neighborhood, community, trade union, church organization or nation. In this matter, again, the power of the older mores and folkways may modify and divert the direction of the new solution. Because of the dominance of these cultural habits, the modern social reformer may encounter difficulties in attempting to project, successfully, his pet theories and programs upon his group. Accretions to the mores are gradual. Nevertheless they do arise out of personal-social experience in the first case, modified always by past cultural norms.

The third factor to be taken into account in social psychology is the organism itself. First, we must consider it in its individual or psycho-biological dimensions, and then in the sense of a developing, changing person. On the side of the psycho-biological individual, we must examine his physical, intellectual and emotional make-up in terms of behavior mechanism and variability in structure. As the organism is thrown into the social milieu at birth, the psycho-biological mechanisms are directed toward this environment from the beginning of life. The earliest environment of the child is colored by social influences. It is out of the interplay of organism and environment, personal-social and cultural largely, that the personality is developed. What the person becomes depends largely upon the group contacts and their effects upon his organic nature.

The organic nature of man determines, in part at least, the whole personal-social and cultural environment itself. When we observe the person in

[7] This is not to gainsay that consideration of other aspects of environment, physical and biological, is necessary to a full treatment of the social-cultural process.

[8] See my "Social Psychology: An Analysis of Social Behavior," 1930, for a treatment of the difference between personal-social and cultural conditioning.

operation in relation to other personalities, we see that emotions and feelings as well as intellect must be taken into account. The former furnish the basic drives or motives to conduct. The latter is largely given over, apparently, to rationalizations and conscious adjustments on the one hand, and to furnishing the internal or subjective counterpart to our personal-social and cultural environment on the other. That is, the imagery, the ideas and attitudes within the organism reflect very largely one's conditioning to personal-social and cultural factors in one's experience. In this manner they pre-determine to a large degree how one will respond to future personal-social and cultural stimuli. In other words, the social psychologist examines not only the mechanisms of conditioning and integration of responses, but that content of ideas and attitudes which have been accumulated from experience. This content is what Thomas refers to as values and what Znaniecki and Faris term social objects. Biologically, the seat of this content seems to be largely the cerebral cortex, for it is through this section of the central nervous system that learning takes place. With all these effects, left over from conditioning, go profound emotional and feeling accompaniments. And the biological roots of the emotions and feelings lie in the autonomic-glandular system which is the result of inheritance and maturation.

If present-day social psychology exposes man as largely irrational and emotional, rather than as coolly rational and intellectual, it is because the evidence seems overwhelmingly to show that behavior is motivated by deep prepotent emotional-feeling trends. Upon them the personal-social and cultural influences work their way. The amazing thing is not that man is not the rational, calmly intelligent person in his social contacts that he was once pictured, but that social and cultural conditioning, after all, can so profoundly alter the direction which the prepotent tendencies take.

The writer is of the opinion that the recognition of this fact will go far in giving a more satisfactory direction to any social reform or change which groups may wish to undertake in the interests of society and individuals. The writer does not believe that progress, whatever it be, lies in the direction of crushing out the emotions and feelings and substituting the reign of the intellect. It consists in directing, by the best knowledge we have, the emotions and the feelings into those channels which the social ethics of the time, themselves based on a recognition of the place of emotions and feelings, dictate. Science alone can not save us, unless we couple with it an art and philosophy which will recognize the power of emotions and feelings in the motivations of human conduct.

SCIENCE SERVICE RADIO TALKS

PRESENTED OVER THE COLUMBIA BROADCASTING SYSTEM

THE UNITY OF LIFE

By Dr. C. E. McCLUNG

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THE astronomer finds in the heavens a multitude of celestial bodies, which he classifies as stars, planets, satellites, nebulae, comets, meteors, asteroids, etc. He traces the birth, maturity and senescence of universes and, by spectroscopic analysis, discovers that all these varied heavenly bodies contain the same chemical elements. Our own earth, once thought to be the center of the Universe, takes its place as a minor unit of one galaxy. System, law and order prevail—an underlying unity pervades the apparent diversity.

Because of the ability of the physical scientist to predict the coming of future events, his opinions are accepted with little question, even when they come into conflict with our most cherished beliefs, but quite the opposite is the case when the biologist speaks upon the nature and relations of living things. Here we often hearken back to medieval times. State laws are enacted practically forbidding people even to think upon biological matters under penalty of imprisonment. People who admit their incompetence to pass upon astronomical questions will categorically deny the validity of biological theories which have the support of all scientists. The reason for this, of course, lies near at hand—every person is in himself a living being and, therefore, considers himself prepared to pass judgment upon matters relating to his class. Unfortunately, he overlooks the fact that in addition to this general qualification, the biologist has given years of special study to the problem and therefore, if there is any virtue in mental application, should be much better qualified to think and judge in such a difficult matter.

The problem of how living things are related may be stated in its general terms very simply. There are now dwelling upon the earth some millions of different kinds or species of animals. A study of geological history shows us that in past ages many more millions of kinds existed and died off. The main question at issue is: are these manifold forms related to each other, or did each originate independently—these are the only alternatives. I do not wish to argue the question on this occasion, but merely to present some of the evidence upon which a reasonable decision must be based.

The facts usually taken into consideration are those relating to structure, because they are the ones which most clearly and easily distinguish one kind of animal from another. Amid these admitted diversities, degrees of resemblance are sought and used as measures of relationship. Logically this seems to be little justified as a primary approach to the problem. If it is believed that all animals are related to each other, then search should be made for qualities common to the entire group. If many millions of kinds of animals are alike in a series of essential characters, then the assumption that they arose independently becomes mathematically improbable.

What are the admitted resemblances between animals? First, there is the limited range of physical conditions

which they require for existence. So far as the astronomer can discover, our earth is the only celestial body which presents these conditions fully. Sunlight, water, oxygen, a limited amount of carbon dioxide, a narrow range of temperature variation, and many other circumstances must be present in their entirety for life of any kind to exist. Since it is obvious that an animal is essentially a reaction mechanism, the circumstance that all animals react to a common and unique set of physical conditions argues strongly for their common origin.

The second point of resemblance is that they are composed of the same kind of substance. This common building material is called protoplasm, or primitive substance. It is of a watery, glue-like nature, and has many of the properties characteristic of the class of compounds called by chemists "colloids." Whatever activities animals manifest they are the ones inherent in the basic substances of which they are composed. In some peculiar way this has become, as it were, a time reservoir. Only after repeated and accumulated experiences do modifications become impressed upon protoplasm. There are, therefore, as many kinds of protoplasm as there are of animals, each of which has incorporated into itself the results of its past experiences. In some way this process accelerates with time, so that development and change are cumulative.

In the third place, we note that not only are all animals composed of the same kind of substance, but they have it organized into the same sort of structural units. It is just as if all houses should be constructed of baked clay which had been formed into units, or bricks, of different sizes and shapes. Only in very recent times have we known these living building blocks, because they are very minute and require the highest magnification of the microscope for their study. The discovery that the unit of structure and function in both plants and animals is this so-called cell is perhaps the most important in all biology. Our understanding of how living things are formed and how they act depends upon our knowledge of the nature and behavior of these organic units. It has been well said that all problems of modern biology are cellular problems. Practically this means that whatever we discover about any one cell has meaning for all cells. Some of the most fundamental facts relating to the nature of vital processes in man have come, for instance, from the study of cells in insects and even in plants.

Finally, we observe that no matter how varied in size and form animals are, they perform just a few striking and unusual acts necessary for their existence —in other words, they relate themselves in limited and specific ways to their common environment. There are manifold degrees of speed and perfection with which these acts are performed, dependent upon the structural mechanism employed in each case, but, whether high or low, all animals are alike in the things they do. What are these unique vital functions?

First, since animals are absolutely dependent upon their environment, they must be able to sense this so that they may adjust themselves to favorable and to unfavorable conditions, *i.e.*, they must have the power of perception. They must be able to distinguish between light and darkness, heat and cold, food and poison, friend and foe, and so on. This is due to a property of protoplasm known as irritability.

To take advantage of perceptual reactions, animals must be able to move. This faculty is highly developed in animals and depends upon a quality of protoplasm called contractility. Certain cells are modified in a characteristic manner so as to make possible a large degree of contractility. In higher animals these are called muscle cells, and

they are much the same whether found in insects or in man.

To produce movement or any change, energy is required. In animals this is secured by burning up their substance. Such losses are made up by taking foreign materials and transforming them over into the nature of those destroyed. The body of an animal is like a chemical laboratory where there goes on a constant series of destructive and constructive processes. These chemical changes come under the designation of metabolism and, again, are common cellular processes in all animals.

But the most striking and entirely unique characteristic of living things is their ability to reproduce themselves. Given the necessary physical conditions and protoplasm, as such, is immortal, but its various embodiments are constantly wearing out and dying off. To secure the perpetuity of their kind, animals accordingly reproduce themselves, and so there is a constant succession of individuals of any given variety, some of which forms go back for millions of years. Here again, we deal with a cellular process, for each animal at one time in its existence is a single cell and becomes a body of billions or trillions of cells through the reproduction of the original one. It is probably true that, in turn, all the parts of the cell reproduce themselves down to the chemical units which compose them.

What has been asserted of animals is essentially true of plants also. Our knowledge of living things, including man, enables us, therefore, to state the following facts: (1) they are made up of one kind of substance, protoplasm; (2) this common material is organized into a single type of unit structure, the cell; (3) these cells are differentiated for the performance of a common series of functions and (4), for the performance of these acts, a very limited series of physical conditions, unique in their combination, is required. When viewed from the functional standpoint, the manifold diversities of form in animals are, therefore, only adaptations to secure various degrees in expression of a common and essential series of vital processes.

ANIMAL GRAFTING

By Professor H. H. COLLINS

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WE are inclined to think of that rarely gifted and many-sided American, Benjamin Franklin, as a man of a very practical turn of mind. We remember him not only for his achievements as a statesman, but also as the author of "Poor Richard's Almanac." Less well known is the fact that he was one of our pioneers in the field of science, and that, in the course of his investigations, he sometimes performed experiments such as his flying a kite in a thunderstorm, in which the Poor Richard type of mind might well fail to see any rhyme or reason. Electricity, in which Franklin was greatly interested, after being, as skeptically minded persons were wont to say, nothing but a college professor's toy for a century and more, finally came to revolutionize human daily life,—and the end is not yet.

Many of the experiments of modern biologists might well be compared to Franklin's kite-flying venture. Just as in the realm of electricity a study of the behavior of this mysterious force under every conceivable set of conditions ultimately led to the discovery of means of

harnessing it for the service of mankind, so the study of living matter under all conceivable experimental conditions may be expected to lead to a knowledge of life with possibilities of its control in ways undreamed of today.

The very important place which plant grafting holds in agriculture is a matter of common knowledge. Less well known, however, are the results obtained in the grafting of animal tissues. As in plants, pieces of two different individuals may be joined in permanent union.

In animal grafting the individual receiving the graft is known as the host; the one from which the graft is taken is the donor. Grafts take most readily when the host and donor are one and the same animal. Grafts between different species or still more distantly related animals are difficult, if not impossible, to make, due to blood incompatibility.

Transplantations are easier on embryos than on adults. Before the brain and blood circulatory system are developed the head regions of two frog embryos may be successfully interchanged, but this would be impossible in adults. Heads may be interchanged in adult insects. This is possible because in insects, the body structure is such that removal of the head does not seriously interfere with breathing and circulation. Certain worms may be cut in two and the body of a second worm of the same kind inserted thus making an abnormally long worm. In certain instances, two animals may be joined together side by side, Siamese twin fashion. This has been done with rats, birds, frogs, and newts. This type of operation is actually a blood transfusion experiment on a large scale. Animals of opposite sexes have been united in this manner in order to study the effect of the secretions of the ovary and testis upon the development of the so-called secondary sexual characters.

Among various scientific problems attacked by the method of tissue transplantation, one of the most important is that of the influence of the host on the graft. One of the classic experiments in this field performed some years ago was the transplantation of the ovary of a black guinea-pig into a white guinea-pig whose ovaries had been removed. The offspring of this white female mated with a white male were *black*. Normally the offspring are white when both parents are white. In this case the graft was uninfluenced by the host. Experiments of this sort should however be continued through a longer period of time in order to determine whether or not some change might eventually become evident.

Parts of the body of an animal of one species have been grafted on an individual of another race or species to determine whether the specific characters of the graft can be changed by the influence of the host. It has been found that the rate of heart-beat differs in embryos of certain species of amphibians. When the heart is transplanted from one species to another, it maintains its own characteristic heart-beat. Specific differences in rate of growth and in size of body parts have also been observed. These differences may persist for a time following transplantation, but, in general, are gradually brought under control of the host's growth regulatory mechanism.

Not only does the host, in varying degree, exert an influence upon the graft, but the graft may affect the host. The most striking effects of this sort are produced by the secretions or hormones thrown off by certain types of grafts into the blood stream of the host. A graft taken from a hormone secreting organ may produce profound changes in the host. Animals engrafted with ovaries or testes, for example, assume more or less distinctly the characters of the sex of the animal from which they received the graft.

One of the profoundest problems which confront students of life in its various manifestations is that of the gradual development of a highly complex adult body with its many kinds of very dissimilar and highly specialized types of cells, tissues, and organs from the relatively simple fertilized egg cell. Soon after fertilization, the egg cell divides into two cells, identical in appearance. These divide and the process continues, but the daughter cells gradually become more and more unlike until finally the muscle, bone, nerve, gland, and cells of many other types appear. Some interesting discoveries have been made in studying this problem of the development of embryos by the transplantation of tissues from one embryo to another, or from one part to another of the same embryo. It has been found that certain groups of cells may for a time control the development of other groups of cells. The lens of the eye develops in the embryo from the small area of skin beneath which the rest of the eye comes to lie after growing out as a stalked structure from the brain. In certain amphibians, the cells in this so-called optic cup force the overlying skin cells to form the lens. If this patch of embryonic skin cells is excised and transplanted to any part of the body it becomes a part of the normal skin of the adult animal. If skin from any other part of the body of the embryo is placed as a graft on the side of the head above the optic cup, it will differentiate to form the eye lens. However, if the lens area has started to develop as lens, it will grow into lens although transplanted to some other region of the body.

At a certain stage in the development of the amphibian embryo a mass of cells lying just underneath the developing brain acts as a controlling organization center for surrounding tissues, determining their fate. When this mass of cells is grafted into the undifferentiated abdominal region of another embryo, it induces there the development of a second brain and spinal cord from cells which would normally have formed stomach, kidney and other abdominal organs. This particular organization center soon loses its controlling power, later development apparently being controlled by a succession of organization centers which arise in various parts of the body.

In the work in the field of animal grafting being conducted in the laboratories of the Department of Zoology of the University of Pittsburgh, a small am-amphibian relative of the common frog is being used as experimental material. This form is commonly known as the red-spotted newt, in some localities erroneously called the "water lizard." This small animal which has somewhat the appearance of a miniature alligator has a very striking color pattern over the general body surface.

The under surface of the body is a bright lemon yellow, with numerous rather large black spots, fairly uniformly distributed. In sharp contrast to this, the animal's back is a dark greenish brown, mottled with black splotches and further marked by two rows of brilliant red spots, one on either side of the mid line of the back. The two types of skin do not shade gradually into each other along the sides of the body but are separated in very clear-cut fashion along what we have called the lateral border. How such a color pattern could have arisen in the evolutionary process, we are at a loss to determine. Equally mysterious is the development of this pattern in the embryo. In the growth of an individual from the egg to the adult, cells as unlike as those of the brain and liver develop from common ancestral cells. The differences in coloration of the skin on upper and lower surfaces of the body may be due to differences between the skin cells of the two body sur-

faces, slighter in degree than those between brain cells and liver cells. Another possibility is that the difference in coloration may be due to difference in location. It is known that in early stages of the development of an embryo the ultimate fate of cells is determined by the position they happen to occupy. If we could interchange the two cells, one of which would normally ultimately give rise to brain, the other to muscles, the ancestral brain cell would produce muscle cells, the ancestral muscle cell, the brain.

To determine whether the marked differences in dorsal and ventral skin of these two types were fixed and unalterable or due merely to difference in location, skin transplantation experiments were carried out. The animals were anaesthetized and small patches of skin were removed. These grafts were rotated through 90 and 180 degrees and replaced in the original location. The animals were kept for 24 to 48 hours under an anaesthetic. When they recovered none the worse for the experience, and resumed their normal movements, the grafts remained in place, the cut edges of the skin having united during the inactive period. Lemon yellow ventral skin of the graft was now surrounded by dark dorsal skin, and *vice versa*. During a period of several months after operation, the grafted skin slowly became reorganized and assumed the appearance of the surrounding skin. In some animals, the reorganization is exceedingly slow and is incomplete more than a year after operation.

In the process of reorganization, the little black color or pigment cells appearing under the microscope like miniature tree stumps with many roots, behave in a very characteristic fashion. Yellow skin grafted upon the back is slowly invaded by hosts of black pigment cells from the surrounding dark skin. Some of these invaders become clumped together to form large dark spots, while most of them remain scattered to form the dark background characteristic of the normal dorsal skin. The red pigment in the brilliant spots appears to exert a strong attraction on the black cells. The black cells crowd about the red pigment spots, forming a dense black border. We do not have as yet any explanation of the behavior of these pigment cells. The slow reorganization of the color pattern indicates some differentation, but the two types of skin do not have their characteristics fixed and unalterable. Placed in a foreign environment they gradually conform to that environment. While it may be true that a leopard cannot change its spots, a salamander can.

Among the relatives of the red-spotted newt of the eastern United States is the brown newt of the Pacific slope and a newt of similar appearance found in Japan. Skin grafts have been interchanged between these species with interesting results. The more distant the relationship between the animals the greater the violence of the reaction, the foreign tissue being resorbed and replaced by host tissue. In this group of animals skin grafts seem to afford a very delicate test of relationship through the differential rate of resorption of the grafts. According to the evolutionary theory of the origin of the many kinds of animals in the world today, all living beings are blood relatives of each other. In the working out of family trees nearness of relationship has in the past been based mainly upon the degree of resemblance in anatomical structure. To some extent these relations, inferred on the basis of structure have been verified by blood tests. The method of skin grafting appears to offer an additional and exceedingly sensitive means of determining evolutionary relationships.

HOW SCIENCE STUDIES THE CHILD

By Dr. ARNOLD GESELL

DIRECTOR OF THE YALE CLINIC OF CHILD DEVELOPMENT

SCIENCE is a mixture of curiosity and reasoning. It represents the determined, systematic effort of man to understand the world in which he lives. The child is part of that world—a very important part. The child is a portion of the scientifically explorable universe, quite as much as the sun, the stars and the ether. Prompted by curiosity and by the needs of civilization, the physical sciences are penetrating the mysteries of heaven and of earth. There is now a huge fund of knowledge which gives increasing control over the natural forces of the physical world.

In comparison, our knowledge of the child is meager. But the child is part of one vast order of nature, within the scope of science. The laws which govern his behavior and his development are discoverable. He challenges the same scientific inquisitiveness which impels chemist and physicist to investigate the constitution of the atom. The child is more complicated than the atom, but not less lawful. The very conquests of physics, chemistry and engineering have created new problems for society. Our mechanical civilization has grown so complex that we can not perpetuate it without a deeper comprehension of human nature. Each generation must rear a stronger army of children, mentally fit to carry forward an increasingly complex culture. As a measure of self-protection and of survival, the race must learn new methods for improving mental stamina and psychological adaptability in the young.

Consequently, the scientific study of child development has expanded at a very rapid rate in recent years. Centers of child research have sprung up at points as far flung as Moscow, Geneva, Vienna, Berlin, California, Iowa, Minnesota, Washington, New York. America has become a leading country in this scientific movement. Everywhere our universities are establishing laboratories, nursery schools, guidance clinics and institutes for the investigation of child development. Infants and young children are no longer strange sights on a college campus. They have become part of the scheme of science and of education. And this has had a humanizing effect on all concerned. Adults have benefited along with the children.

At present we know as little about the psychology of the child, about the nature and the needs of his mental life, as was known about the geography of the world at the time of Columbus. There are large, almost unknown continents of truth into which hundreds of investigators have entered. An important field of exploration has to do with the significant problem of individual differences of perception, of memory, of speed and accuracy, of movement, differences in posture, in imagination, intelligence, endurance, talents, interests, skills and aptitudes. Even in such a simple trait as right-handedness or left-handedness there are individual variations. These variations are being investigated by methods of careful measurement, by comparative observations, and by intensive individual studies. Sometimes children are observed continuously night and day, or at brief intervals, or over a period of years.

Instruments of great precision are frequently used. Reactions are recorded on strips of waxed or smoked paper; movements are photographed; stenographers register full details; even sensitive electrical apparatus, like the galvanometer, may be brought into use. Literally hundreds of mental tests and

scales have been devised to measure human differences. When an amateur without scientific training or scientific standards attempts to apply these tests they become useless and misleading; but when applied with critical caution they are valuable. We must remember that mental measurement is only in its beginnings. The time will come when the sciences of human behavior will have techniques which will not only measure the capacities of the child but will predict and guide the development of his characteristics.

To study the genesis of individual differences it is necessary to study the processes of mental growth. The mind grows. Behavior grows. This growth begins even before birth. It expresses itself in changing patterns of behavior. So swift and continuous are the changes that it is difficult to keep up with the pace that the infant sets. In the Yale Clinic of Child Development we have had to call to our aid the motion picture camera. The cinema sees with an all-seeing, impartial eye and it records with an infallible memory. We need such a powerful recording instrument for the exploration of the bewildering and almost kaleidoscopic eventfulness of human infancy.

Normal infants are periodically studied at four-week intervals throughout the first year of life with the aid of a specially designed clinical crib which permits the application of psychological test situations under controlled conditions. The crib is housed in a hemispherical photographic dome equipped with a one-way vision screen which permits free observation by effectively concealing the observers stationed outside. The dome is equipped with cinema cameras which make permanent systematic records of the behavior characteristics of the infant—his posture, locomotion, perception, prehension, manipulation, social reactions and spontaneous and problem-solving activities. Simple test materials like small red cubes, pellet, string, bell and formboard are used to call out characteristic patterns of behavior.

The cinema captures this visible behavior. The records are then subjected to detailed analytic study by means of a specially designed projector which throws the image of the behavior on a viewing glass. The infant relives on the cinema screen. We can see him as he was at four weeks, eight weeks, twelve weeks, sixteen weeks, and so on. By simultaneous projection we can make an immediate comparison of any two age levels of maturity. By such methods it is possible to measure and to chart the patterns of behavior which express the laws and norms of early mental growth.

Many studies both in this country and abroad show that important individual differences declare themselves early. Take, for example, such important traits as artistic and musical ability, drawing, dramatic and mechanical abilities. They have been studied at many age levels. Recent research has pushed the quest for early indicators down to infancy and the preschool years. If scientific progress continues at the present rate, it will be possible for later generations to detect individual variations from the normal at very early ages. That will lead to prevention and cure of many behavior disorders. It may some time also be possible to discover gifted individuals of the community in the cradle and the nursery. Indeed, it will become necessary for future society to greatly perfect the education of all children in the first five fundamental years of life. Science alone can determine the scope and the hygiene of that fundamental education.

What are the limitations of education? What are the relationships between heredity, environment and development? This is an important field of inquiry, approached from many angles. Numerous comparative studies

are under way, dealing with children from different stocks and races; from different social levels; from different family origins and contrasting educational opportunities. There is a large and growing literature on twins. The study of twins has almost become a science in itself. Identical twins and dissimilar twins, twins reared apart, twins reared together, have been compared and intercompared; their psychological traits, their diseases, their crimes, their achievements, their relative responses to different methods of training have been investigated. Identical twins are an experimental touchstone to the old and fundamental problem of nature *versus* nurture.

The great problems of inheritance, however, are being solved through study of plants and animals as well as of children. The biological sciences are all closely related and they draw upon each other. The more fundamental laws of growth and development are universal. Science seeks and finds truth everywhere. Many of the important facts that we know about the nutrition, the disease, the nervous system, and even the behavior of children have come in a roundabout way, through the study of plants and animals in the laboratory. We must be duly grateful for what the scientist has learned from the white rat, if not grateful to the white rat itself!

The child is part of the whole order of nature. To some degree his growth is governed by the same wonderful laws which control the growth of plant and animal organisms. But the child is also enmeshed in an invisible web of social relationships. His spiritual growth depends upon this web of human relationships. Science must study him as a social being in reaction to parents, to brothers and sisters and to companions. By investigating the growth of his social behavior from the moment of birth it becomes possible to define the laws and the processes of personality formation. Here lies the ultimate goal of child research.

Science may never solve the deeper mysteries of the soul, but it has already begun to cope successfully with the interpretation of human personality. Numberless studies emanating from laboratories, clinics, schools and hospitals have described varying patterns of personality in health and disease. These studies, too, are being pushed backward to the stages of infancy and early childhood. Human personality begins to loom up as something tangible, which in measure can be understood and controlled.

Our scientific knowledge of child personality is still meager and imperfect. But if this present meager knowledge could be put into application it would perceptibly improve the social and the family life of the nation. Even difficult human problems yield to the methods of science. And some of the most perplexing of these problems will be solved by delving deeper, through child research, into the processes of personality formation.

SCIENCE AND THE RADIO

By AUSTIN H. CLARK
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RADIO broadcasting in its relation to science is a rather complex subject which is divisible into three more or less distinct sections. The first of these sections concerns the audience, the second the radio stations and the third the scientific organizations.

At first sight it may appear that these divisions of the subject are given in quite the wrong order—that the scientific organizations should receive the first consideration. What is the reason for the reversal of this order?

The reason is that success in any undertaking is based upon a thorough appreciation of the grim realities inherent in that undertaking. We must understand the basic principles involved and be prepared to accept the situation as we find it.

The situation in regard to radio talks is very simple. The expenses connected with all radio talks are ultimately paid by the audience, and the success of any series of radio talks is dependent upon the willingness of the audience to continue to pay the bills.

The immediate expense of broadcasting is borne by the radio station. Nearly all radio stations are operated for the purpose of making money in one way or another, largely indirectly. Radio stations, therefore, can afford to add to their programs only such talks as will increase the number of their listeners, or at least will not cause it to decrease.

Through the radio stations scientific organizations are enabled to reach a large section of the public at practically no expense to themselves. They are the beneficiaries of a large amount of valuable advertising which, though received without cost to them, means a considerable expense to others, who are quite justified in anticipating that this expense shall in some way be counterbalanced.

So it is evident that in any discussion of the relation between scientific organizations and the radio the audience must be first considered, then the radio stations, and the staffs of these organizations must be prepared to pay due regard to the idiosyncrasies of the one and the necessities of the other.

Consideration of the audience and the radio stations demands as a prerequisite a severe deflation of the ego—especially on the part of the members of the staffs of scientific organizations. We must lay aside the idea that others wish to be like us, or wish to know as much as we do or are to any appreciable degree interested in what seems all-important to us. We must meet the public on the basis of the highest common divisor, intellectually speaking, always, of course, with the hope that this highest common divisor may be increased by our efforts.

The radio audience is composed of the general mass of the population—or rather of a cross section of the general mass of the population. Nearly all those who listen to the radio are more or less typical products of modern American education as it is administered in our public schools.

Education in this country formerly consisted chiefly of a close application to the works of Euclid, Vergil, Thucydides and others, stimulated and invigorated by a liberal use of the birch rod or its equivalent. In spite of its many faults, this system of education had many advantages. Among other things, it inculcated a great respect for knowl-

edge and for individuals possessing an exceptional amount of knowledge. For in those days knowledge, as represented by the teachers, was combined with power—disciplinary power—symbolized by the birch rod.

In our modern public schools the birch rod, the emblem of the dignity, authority and power of knowledge, and hence of the learned, exists no longer. Vergil, Thucydides and the other Latin and Greek authors, symbols of a respect for the knowledge and culture of the past, have either completely disappeared or are in more or less total eclipse.

Education with us at the present day has become a matter of presenting information as nearly as possible in the form of a pleasant amusement, with an underlying idea of its potential economic value rather than of its cultural significance. Through their parents modern American children are induced to accept an education on the basis of a potential development of increased possibilities for accumulating dollars, whereas in the past children were forced to become educated in order that they might maintain the proper cultural level.

So the children in our public schools have little respect for their teachers, and consequently little respect for the learning that they represent. In our colleges the majority of the students listen respectfully to the professors because they or their parents have paid for that privilege, and expensive professors, like highly paid "movie" actors, are always more highly regarded than cheap professors.

This is not an indictment of our system of education. It is really an admirable system—the only system that is applicable to our entire population, and the only system which, in view of our traditions, would stand the slightest chance of success with our public as a whole. Vergil, Thucydides and the birch rod could never be imposed upon more than a very small percentage of any population, though they are exceedingly effective where they can be applied.

But this system of education leaves a very definite imprint upon the radio audience. Composed of individuals with active minds unfettered by any great respect for the traditions of the past, who have been subjected to a suggestive rather than an intensive education, the American public in its leisure moments naturally turns to the sensational and mysterious rather than to the cultural or informative aspects of affairs.

The public looks to the radio for amusement or diversion in some form or other. In the evening especially it craves the sensational and mysterious, the effect of a day's work on most people being to make them intolerant of any close contact with the realities of life—excepting murders, scandals and similar and comparable phenomena.

Most people are more or less optimistic up to lunch time, then apathetic, and after the close of the working day still more apathetic or even pessimistic. Sensationalism, therefore, is least appealing in the morning, and most appealing in the evening. This unconscious leaning toward sensationalism and distaste for any unnecessary contacts with the hard realities of life is accompanied by an unconfessed resentfulness toward education as that term is generally understood. The people have not the least desire to be educated after the fashion in which they were educated in school.

So radio talks given in a manner even remotely suggestive of a desire to instruct are bound to be pathetic failures. They must be wholly devoid of any suggestion that the speaker is better informed or more learned than the listeners. If after leaving school the public is to be induced to continue the acquisition of knowledge, the additional knowledge must be presented either in a form capable of potential interpreta-

tion in terms of dollars, or in the form of a more or less fascinating mystery.

We must constantly bear in mind that as a people we have no real respect for learning as such, and no respect for learned men unless they happen to be in positions of power of one sort or another.

At the present time the power of knowledge in our schools is symbolized by the text-books. Most pupils in the public schools have more respect for their books than they do for their teachers. A very important effect of the use of text-books in schools is to inculcate a feeling that printed information is reliable and authoritative wherever found. Most people in later life carry their respect for the printed page of the text-book over to the printed page of the newspaper, excepting only in regard to matters that concern them personally, or in regard to which they happen to possess special knowledge.

This makes of the daily press a very powerful factor in general education—indeed, the most powerful factor.

In the average mind information acquired from a book or from a newspaper bears about the same relation to information heard over the radio that established fact bears to gossip. Most people, before they are willing wholly to accept news of a startling or unexpected nature heard over the radio, wish to see it confirmed in print.

It must be constantly borne in mind that the radio is to a large extent a sort of family institution. There is nothing secret about it. Every one can hear what the loudspeaker is saying. From this obvious fact arise various complications and limitations which do not appear in connection with the printed page.

Theoretically, father is the head of the family. But not at all infrequently father's prestige is none too well established. Consequently, father is very sensitive. He does not care to hear the loudspeaker telling him in the presence of mother and the children—especially the children—facts of which he is ignorant. It is particularly obnoxious to him to hear the loudspeaker recite facts of which he is quite aware the family knows he is ignorant. Father is often equally sensitive about having the children hear facts from what he regards instinctively as a more or less irresponsible source, far more sensitive than he is about their learning the same facts—or even absorbing information characterized by a complete absence of facts—from a Sunday supplement.

Yet in spite of all that has been said, our American public is keenly and honestly desirous of learning new facts and new ideas, and surprisingly adept at understanding and appreciating them. In imparting new facts and new ideas the one condition to be met is that they shall be conveyed in such a way as not to put any one at a disadvantage through an implication of personal inferiority.

This is not a difficult condition to meet if it is thoroughly understood and appreciated in advance. The chief obstacle in the way of an adequate appreciation is that our educational system as a whole operates under two widely different sets of traditions, the purely native and thoroughly American traditions in the main underlying our public school system, and the imported and alien traditions out of which have grown most of our higher institutions of learning.

Why should the popular attitude toward science, and learning in general, be so very different in this country from what it is in England? The reason is very simple.

The one and only thing that commands general respect is power.

A hundred years ago in England power was to a very large extent hereditary. So far as possible, wealth and power were concentrated in certain

families in which they were handed down from generation to generation. Those who inherited wealth and power were relieved of the necessity for striving to create power and wealth on their own account. They could, if they so wished, occupy themselves entirely with unpractical affairs. This many of them naturally did.

Almost anything a man of great wealth and power may do will be considered praiseworthy, no matter how ridiculous the same line of activity might seem if undertaken by a person of no influence. The hobby of a man of great power is always respected in proportion to the power he possesses, never through any real appreciation of the cultural or other possible values of the hobby itself. These values are later discovered (or invented) and brought forward primarily as an explanation of the superior mental equipment of the man of power—or in other words as a sort of excuse for actions that otherwise might seem peculiar.

Because of the great power which they possessed, no one thought of smiling at the Earl of Seaforth because he collected butterflies, or at Lord Valencia because he collected various animals on his travels, or at Sir Hans Sloane because he spent most of his time in Jamaica, whither he went as physician to the Duke of Albemarle, collecting plants and animals. Indeed, on Sir Hans' death Parliament, representing the British public, accepted his library and collections of all sorts on behalf of the nation, paying his executors twenty thousand pounds for them.

So in England it naturally came about that science and learning early became invested with an enormous prestige that had its origin not in any real appreciation of their intrinsic or cultural value, but arose from the deep appreciation of and wholesome respect for the immense power wielded by the classes to which they were largely confined.

Hand in hand with this went the idea that science, in order to be really respectable and worthy of emulation, must be pure science, as far removed from any possible economic application as its patrons were from the necessity for daily toil.

The English attitude toward science prevailing a hundred years ago was of course imported into this country. But here it failed to make any general impression. It took root in a few places, where it was confined to—perhaps more correctly besieged within—a few institutions of learning and learned societies, almost exclusively in Philadelphia and Boston.

Why this was so is not at all difficult to understand. Our social system was very different from that of England. Our inheritance laws were such that it was impossible to perpetuate power in successive generations indefinitely, and public sentiment was strongly opposed to all efforts toward that end.

The natural result of this was to exaggerate the importance of the personal accumulation of wealth, and hence to regard all forms of human activity in the light of their bearing on the accumulation of wealth.

In a new country with abundant unexploited resources the accumulation of wealth requires abundant energy and resourcefulness. Only a very limited amount of special knowledge, chiefly of the labor foreman type, is necessary. To those whose one aim in life is the accumulation of wealth, hobbies seem ridiculous and a waste of time.

So any appreciation of science, culture or learning was conspicuously absent from the American social ideals of one hundred years ago, excepting only in a few very limited groups which clung to the English traditions.

During the past century, and especially within the past twenty-five years,

appreciation of science has vastly increased in this country. This increase in the popular appreciation of science has been based not upon its cultural aspects but instead has kept pace with its ever-broadening economic application—in other words, with its increasing value in terms of dollars.

At the present time science is more generally and more highly appreciated in this country than in any other, and more money is annually spent for research here than anywhere else. But in the minds of the great majority of our people science never has attained, and never will attain, the high plane of social respectability that it occupies abroad. It is useful and often mysterious, and therefore interesting and worth knowing something about. That is our typical American attitude toward science.

We who do our work in scientific institutions or in institutions of learning naturally see science from the English view-point. We like to flatter ourselves that we are engaged in a thoroughly respectable and even aristocratic occupation. It is a very satisfying and comforting belief, helping to smooth our path through life and doing no harm to any one.

But when we attempt to explain our work to others through a medium which, like the radio, reaches all classes, and chiefly those classes of the population that are most widely different from the academic, we must see ourselves as others see us if we are to achieve success.

CAUSE OR CHANCE?[1]

By Dr. PAUL R. HEYL

U. S. BUREAU OF STANDARDS

It has become almost a platitude to speak of the present period in physical science as one of iconoclasm. The past third of a century has called into question and modified or wholly discarded most of the theoretical principles which had been formerly regarded as permanently established. Matter itself has lost its individuality and has taken its place as but one more mode of manifestation of that Protean concept, energy. The doctrines of conservation of energy and of matter, once regarded as the twin pillars of the temple of science, have lost their separate validity and have become merged into one broader principle in which each supplements the defects of the other.

But we need not multiply illustrations. One by one the fundamental principles of nineteenth century science have suffered modification or displacement, though not without stout resistance occasionally on the part of some valiant upholder of the established faith. But, as time has shown, none of these champions has been any more able to withstand the advance of the Zeitgeist than was King Canute to stem that of the ocean.

It has been reserved for the past few years to attack what has always been regarded as the most fundamental principle of all. The absence of the usual opposition in this case is probably to be ascribed to the fact that the rank and file of science are not yet generally aware of the new mischief which their leaders are up to. Certain it is that whenever the attention of a small gathering has been called to the situation the expected antagonism has developed with a vigor proportionate to the esteem which has been universally accorded this last fundamental principle. I refer to a certain change of attitude of scientific philosophy with regard to the law of cause and effect.

I think it was Maxwell who compared the student of nature to a person in a room where there were a number of ropes dangling through holes in the ceiling. In pulling any of these ropes certain of the others would move up or down, and it was the business of the investigator to determine by experiments with the ropes the nature of the mechanism in the room above.

Notice that it was regarded as a foregone conclusion that there was such a mechanism, and that the observed motions of the ropes were not caused by somebody upstairs who took a malicious delight in tantalizing and perplexing the investigator below. In other words, scientific thought, even since anything worthy of the name has existed, has postulated a universe of law and order from which caprice or chance was totally excluded.

Such has always been scientific thought, but all thought has not always been scientific. Man has not always regarded nature as a realm of impersonal and unchangeable cause and effect. To the ancients the wind was the breath of Aeolus; the stormy waves of the ocean were caused by the wrathful strokes of Neptune's trident; and the heaving earth gave evidence of the displeasure of Poseidon, the earth-shaker. To primitive man nature was all caprice and no law.

This philosophy lasted long. Roger Bacon, the foremost (and almost the only) man of science of the thirteenth century, still accepted the old belief that

[1] Publication approved by the Director of the Bureau of Standards of the U. S. Department of Commerce.

the moon and the planets were carried about by angels. The scientific attitude has been one of slow growth. It crystallized into definite shape about the time of Newton, and is now old enough to have acquired somewhat of the authority of tradition.

Perhaps no other early work so well illustrates the definite shape which scientific philosophy assumed as Newton's Principia. The full title of this work is suggestive: "Mathematical Principles of Natural Philosophy." Newton assumed that all phenomena of nature could be reduced to mathematical principles, and actually went a long way toward completely proving this assumption, for he was able to reduce all phenomena of motion, whether celestial or terrestrial, to dependence upon the principle of universal gravitation.

That this doctrine fairly represented the current scientific thought of that day is evident from the acclaim with which the Principia was hailed by Newton's contemporaries. It was recognized that he had clearly set forth the antithesis between the old and the new, the abandonment of chance or caprice and the substitution of universal law. Since Newton's day natural law has been the prime article of scientific faith. Though there have always been phenomena which stood aloof for a time and resisted all efforts to bring them into line with the great scheme of things, these were regarded optimistically as unsolved problems, challenges to renewed endeavor. And as one by one many of these obstinate phenomena were subdued the belief grew stronger that law and order, physical cause and effect, were the very stuff of which nature was woven.

It is an illustration of the insatiable iconoclasm of the Zeitgeist that this fundamental principle of cause and effect has not escaped being called to the question, and it is a remarkable thing that such question should have come not from the anti-scientific but from the high priests of science themselves.

This latest skepticism concerns itself principally with the behavior of those recently discovered bodies, the electrons. The phenomena exhibited by these little bodies, the smallest known to us, have always been in some respects puzzling and incalculable, but scientific thought has been optimistic here also, confidently awaiting the ultimate victory. The essence of the new view is that the behavior of an electron is incalculable, not because the problem is as yet too complicated for us, but because, to state it baldly, the sections of individual electrons are not governed by the ordinary law of cause and effect. The new philosophy recognizes that where an individual electron may be at this moment is a matter of observation, more or less imperfect; it admits that where the electron has been in the past is a matter of history; but it asserts that where it will be in the future is a matter not for definite prediction but only of statistical probability.

This doctrine appears to strike at the root of all law and order, and yet, curiously enough, its protagonists recognize the existence of a kind of law on the large scale, but deny that it extends to individual units. The new philosophy is not such a complete reversion to primitive type as might be hastily concluded.

Perhaps the best illustration that we can give of this new thought is one based upon the behavior of units large enough to be familiar if not altogether comprehensible—human individuals.

The behavior of any individual under given conditions is, rigidly speaking, unpredictable. For your belief that I will react in a certain way to my environment you have nothing but a probability, perhaps a very high one, amounting to what you may consider a practical certainty, but never more than a probability. No one can say with absolute cer-

tainty that I will not, let us say, steal money during the coming year. It may be in the highest degree unlikely that I will, so unlikely that you may consider it insulting to harbor any suspicion of me, yet experience shows that occasionally an ordinarily well behaved man may do a most unexpected thing. While no one can say definitely just what you or I or he or she will do, yet with a million such individuals to serve as a basis for prediction it is possible to estimate just how many of them will depart from rectitude during the next year and how much money will be involved in the total sum. Such is the accuracy of this prediction that bonding companies risk their capital on it year after year, and make money. Individually, man is more or less of an enigma; in the mass he is a mathematical problem.

Something very like this is the essence of the latest turn of scientific philosophy. It asserts that the future behavior of a single electron is incalculable. We can not tell whether it will turn to the left or to the right, whether its velocity will be accelerated or retarded. All that we can say is that there is a certain percentage probability of any particular behavior, and that such a prediction is always verified by the result when a sufficiently large number of electrons is taken into consideration. In the electronic realm there is no individual causal certainty. Instead there is something which in a conscious organism we would call caprice. Dirac even uses the term "the free will of Nature." Yet as we pass from the individual to the crowd certain laws begin to appear, but they are no longer causal laws; they are only laws of probability.

Who are those who have adopted this strange way of thinking?

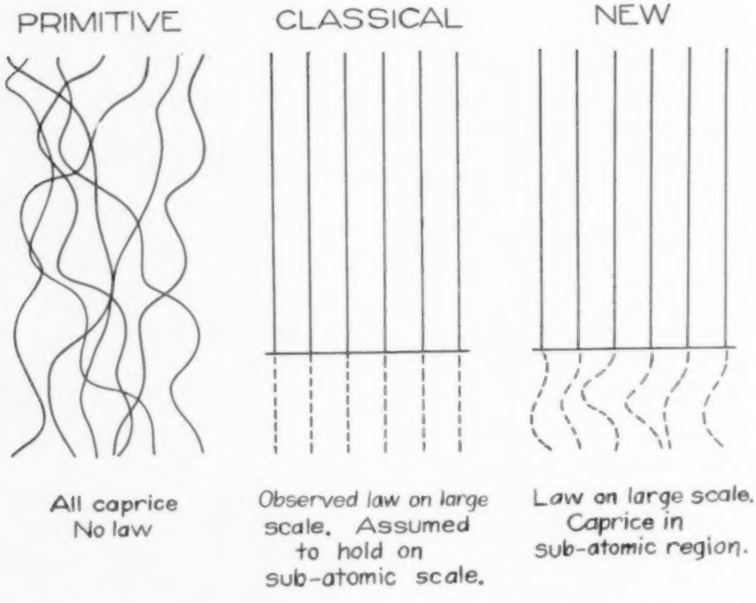
It must be said that there is an imposing array of authority on the side of this new thought—Bohr, Heisenberg, Dirac, Jordan, Born, Eddington, Bridgman and others have contributed in one way or another to its increase and diffusion. It must be assumed that such objections as occur at once to our minds must have occurred also to these recognized leaders, and before condemning the new philosophy *in toto* we should make an earnest effort to get the point of view of those who have been led to support it. It is therefore in order to ask the question which is the proper reaction of all scientific men to every new theory, no matter how bizarre—what is the evidence?

The evidence in this case is circumstantial and cumulative rather than direct and specific, but that is not necessarily a fatal objection.

Bohr began it. His atomic model was never satisfactory and no one was more keenly aware of this than Bohr himself. But he saw no way to improve it, and after much study of the subject he came to the conclusion a few years ago that the difficulties were fundamental, and committed himself publicly to the opinion that an accurate causal description of atomic phenomena on the basis of the classical frame of space-time was impossible.

About this time the new theories of wave and quantum mechanics came upon the scene. The wave-atom concept in particular excited a renewed hope that a causal explanation of atomic phenomena might be possible, but on further development it was found that the wave mechanics in its original form developed about as many new inconsistencies as it removed. When a theory thus runs into fundamental difficulties we have learned to take it as a hint from nature that we are on the wrong track, and that we must either discard or seriously modify our theory.

In the case of the wave-atom it was the latter course that was adopted. The wave concept has been so radically modified that nothing but its outer form is left. De Broglie, the founder of the wave mechanics, expresses this change



by saying that the Schrödinger wave is no longer to be regarded as a physical entity, a vibratory phenomenon actually taking place in space, but merely as a symbolic mathematical representation of the positions and states of motion of the separate electrons. The square of the amplitude of the wave at any point, formerly visualized as the intensity, is on the new view nothing but the numerical measure of the probability that an electron will be found at that point. This converts wave mechanics into quantum mechanics, and therefore E. L. Hill, in the "Editor's Column" of *Physics* for December, 1931, suggests that the term wave mechanics should be dropped altogether.

Such an interpretation of the wave equation of Schrödinger puts us in this position: the solution of the equation gives us not a definite state of motion at a certain point and time, but in its stead a probability function. This change of base avoids certain difficulties inherent in the older wave concept, and gives the theory a new lease of life.

The perspective of the situation is something like this: in attempting a causal and individual explanation of atomic phenomena we have always sooner or later run up against a stone wall. The alternative line of statistical probability avoids this barrier, at least for the present. The successes of the quantum mechanics have been many; no end is yet in sight, and with each success the cumulative force of the evidence increases. Thus on the principle of driving a nail where it will go our line of thought is shaped for us by nature herself.

The first impression which this new doctrine makes upon one trained in the old school is that it is a hasty cutting of a Gordian knot which, with a little more time and patience, might have been untied. The case of the kinetic theory of gases comes to mind in this connection. Out of the apparently random motions of the molecules of a gas there may be deduced certain statistical laws but further study of these seemingly fortuitous motions leads to a causal explanation in terms of mutual collisions, phenomena of an order more fine-grained than those with which the statistical laws are concerned. Similarly, in the

human analogy, it is possible to argue that the behavior of an individual is not due to free will as he likes to suppose, but is a consequence of causal reactions in his brain cells of an order so fine grained and recondite that we are not yet able to follow them. May it not be possible that the apparently lawless behavior of individual electrons is due to causes hitherto unrecognized, and on a scale proportionately fine-grained?

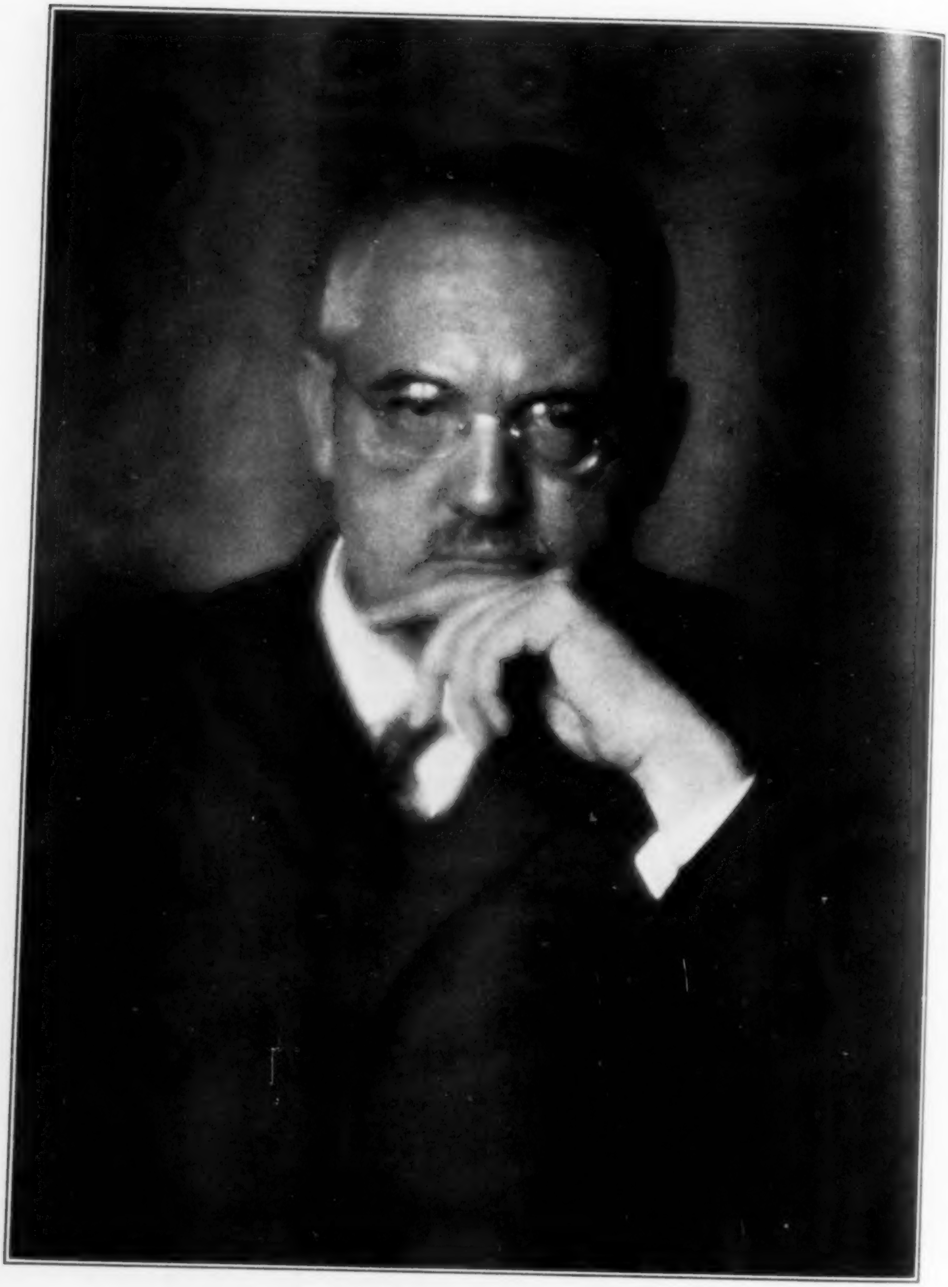
To this objection the upholders of the new make the following answer. The element of incalculability in electronic behavior is not, as might be supposed, entirely a matter of human limitations. There is reason to believe it to be a fundamental characteristic of nature herself, but which from its magnitude becomes perceptible only on an atomic or sub-atomic scale. This is why it has been only recently recognized. This newly discovered characteristic has been formulated in Heisenberg's principle of indeterminacy.

This principle has become familiar, at least in name, to most physicists, but there seems to exist a rather general misconception of it. Many suppose that it states nothing more than our inability to make accurate observations because of the disturbances introduced by the measuring apparatus. Were this all, the principle would be neither new nor worth serious consideration. The vital feature of the principle is not the disturbance of the thing measured, but the fact that there is something essentially incalculable about this disturbance, so that it is inherently impossible to allow for it completely. We can not estimate the magnitude of the interference caused by the observing apparatus more closely than within certain limits which do not depend at all on instrumental or subjective imperfections, but upon something as fundamental and objective as Planck's constant of action.

As the situation presents itself we appear to have two alternatives. We may assume the behavior of electrons to be causal, the unrecognized causes operating being on a scale perhaps as fine-grained in proportion to the electron as those which govern human actions are to our own scale of magnitude. In other words, we may take a deterministic view of nature. On the other hand, we may take the free will position with regard both to man and to the electron, denying causal laws and admitting only statistical laws of probability. It would seem hardly fair to lay the flattering unction of free will to our own souls and deny it to the electron. And if free will is a satisfactory working hypothesis on the scale of our own highly complex organism, which depends ultimately on electrons or something still more fundamental, why should it be unthinkable for a free lance electron?

The situation has been well summed up by de Broglie in one of a collection of essays entitled "Recueil d'exposés sur les ondes et corpuscules," from which I quote the following sentences.

> Causal laws replaced by laws of probability, physical individualities well localized and of well defined movement replaced by physical individualities which refuse to let themselves be simply represented and can never be more than half described: such are the surprising consequences of the new theories. In digging under these laws of probability, shall we succeed in re-finding causal laws as we have found recently behind the statistical laws of gases the causal laws of the movement of molecules? Certain arguments would lead to this belief, but it would be indeed imprudent to assert it.
>
> What we have said suffices, we think, to show the importance of the change in the point of view which has recently taken place in physics. Whatever may be the final fate reserved for these new doctrines, it is of infinite interest to philosophers that physicists have been led, even though but for the moment, to doubt the determinism of physical phenomena and to question the possibility of describing them in a complete fashion within the frame of space and time.



DR. CARL BOSCH

THE PROGRESS OF SCIENCE

THE AWARD OF THE NOBEL PRIZE IN CHEMISTRY TO DR. CARL BOSCH AND DR. FRIEDRICH BERGIUS

THE Swedish Academy of Sciences, in awarding, on December 10, 1931, the Nobel Prize to the two German chemists, Professor Carl Bosch and Dr. Friedrich Bergius, has bestowed this high international honor upon two men whose labor has resulted in the most conspicuous economic achievements of technical chemistry in the last twenty years.

The name of Bosch stands, first and foremost, for the technical development of the high-pressure industry, for the adaptation of Haber's invention—the catalytic high-pressure ammonia synthesis—to large-scale production of artificial fertilizers from atmospheric nitrogen.

Bergius was the first to show that it was possible to crack coal under addition of hydrogen so as to obtain liquid products. His process was running on an experimental scale when, in 1924, his patents were taken over by the Badische Anilin- und Sodafabrik, which had been working on the same problem for some time.

The "Badische," then under the direction of Bosch, basing upon his experience in high-pressure techniques and using catalysts, carried the hydrogenation process to a technical success, not only in its application to coal and tar-oil, but also to natural oil. Especially as applied to mineral oil, hydrogenation is a marked success in respect of both technical perfection of refinery and adaptability to the demands of the market.

If we undertake, in a narrow frame to draw a picture of the two men, we must confine ourselves mainly to one side—their development and their successful working in the service of chemical technology.

Carl Bosch was born in Cologne, on August 27, 1874. At an early age, working whenever he could in his father's installation workshop, he acquired considerable dexterity in metal working and fine mechanics, perfecting this skill by one year's practice in the Marienhütte, Kotzenau, Silesia. In 1894, he went to the Charlottenburg School of Technology for the study of engineering and metallurgy. Two years afterwards, however, he went to Leipzig University, devoting himself entirely to chemistry. He was graduated under Professor Wislicenus, his thesis being: "Über die Kondensation von Dinatrium-Acetondicarbonsäurediäthylester mit Bromacetophenon." His fellow-students at the time praised his manual skill, as, for instance, in glassblowing. Just before the beginning of a lecture, a Röntgen-tube broke; nobody knew what to do, but Bosch repaired it just in time.

In 1899, Bosch entered the service of the Badische Anilin- und Sodafabrik, Ludwigshafen on Rhine. Under the auspices of Dr. Knietsch who employed him in the phtalic and sulfuric acid factories, it was his good fortune to come in close touch with the then fast rising industry of synthetic indigo. Here, his sound training in handicraft, his constructive ability and his wide knowledge of materials found full scope. While engaged upon problems of thermal economy, he discovered improvements, constructing, for instance, a new type of producer to gasify lignite briquettes. It is largely due to his advocacy that at that time coal-heating was superseded by gas-heating, and that gas-engines were installed for cheap motor power.

Soon after 1900 he took up nitrogen fixation which then began to agitate the

DR. FRIEDRICH BERGIUS

minds. He first chose the way via the metal cyanides and nitrides at that time considered the most practicable. In 1907, he put up a trial factory for the manufacture of barium-cyanide according to the Margueritte and Sourdeval process. At the same time he took an important part in the technical development of the Schönherr arc-light process then carried out by the Badische Anilin- und Sodafabrik in Norway.

However, it was not until the "Badische" took over Haber's ammonia synthesis that his abilities developed to the full. He was entrusted with the technical adaptation of the process to large scale operation. Much has already been written about this immense task and its stupendous success. We therefore confine ourselves to a few particularly conspicuous features.

Bosch early recognized that a large-scale industry could not possibly be built up upon osmium and uranium which Haber had found to be the most active catalysts. He and his collaborators looked round for a cheap, easily accessible, contact substance, and right from the beginning he suggested iron on account of its relatively complicated spectrum. With the experience gained in the nitride experiments, they soon succeeded in preparing iron, at that time considered inactive, in such a way as to make it a highly suitable catalyst.

The novel, extremely difficult, constructive requirements conditioned by the adaptation of the high-pressure synthesis from the laboratory scale to a large technical scale, stimulated his inventive faculties. One particularly characteristic example deserves remembrance. In the initial stages of large-scale operation there was not, as yet, the necessary experience to cope with the problem of high pressure combined with high temperature, essential features of the process. It soon showed that the hydrogen diffused through the steel, dissolving its carbon content, thus destroying the strength and tenacity of the pressure pipes. The expensive high-pressure furnaces, soon after they were started, cracked and became useless. There seemed to be no alternative but making the furnaces still more expensive by lining them with silver and gold. One day Bosch surprised with the simple ingenious suggestion to line the pressure-bearing mantle with an easily exchangeable iron tube to bear the attack of the hydrogen. As a protection against the diffused gas the mantle itself was fitted with small holes through which the hydrogen could escape into the open air. This difficult problem was solved.

How far-seeing Bosch was, with regard to the future development of the Haber synthesis, and how optimistic right from the beginning, became manifest by his answer to the question as to how large he thought the high-pressure furnaces would become in the end: "We shall go to the very limit of the German steel industry's capacity!" This at a time when cast-steel blocks were already being made weighing 100 tons.

When the problem of the manufacture of ammonia was solved there followed the second, equally difficult, task of converting the ammonia obtained into valuable marketable products such as nitric acid and fertilizers. Also here Bosch's chemical and technical skill triumphed. Oxidation of ammonia to nitric acid in large furnaces by means of the newly found iron-bismuth catalyst; synthesis of urea from carbonic acid and ammonia; increasingly effective fertilizer salts of all kinds up to the numerous mixed and complete fertilizers—a bulk of patents give evidence of the abundance of his inventive genius.

The crowning of his labors are the two immense nitrogen-works of Oppau (1913) and Leuna (1917).

Yet, his furtherance of the high-pressure industry did not cease even when, on being appointed director-in-chief of

the Badische Anilin- und Sodafabrik in 1919, and president of the I. G. Farbenindustrie Aktiengesellschaft in 1925, he was compelled to occupy himself more and more with problems of organization and economics. His influence is to be felt in the subsequent stages of development not only of the nitrogen industry, but also of the methanol-synthesis and finally the catalytic hydrogenation of coal and oil.

The picture of Bosch as a natural scientist and technologist would be incomplete without a few lines as to his other scientific interests that fill his leisure hours and afford him the necessary recreation. If not constructing a new apparatus in the workshop of his home at Heidelberg, or investigating astrophysical problems in his private observatory, he most likely sits over beetles and plants, or works in his private research laboratory on an old favorite subject—the physical chemistry of rare metals. His interest in the progress of theoretical physics—and his profound knowledge of its very latest achievements, the theory of relativity and the mechanics of quanta—has secured him the friendship of such famous physicists as Einstein and Nernst.

Friedrich Bergius was born on October 11, 1884, at Goldschmieden, Silesia, where his father was director of a chemical factory. He studied at Breslau, Leipzig, and Karlsruhe, was graduated in 1909 at the School of Technology, Hannover. There he maintained a private research laboratory, investigating the effect of high pressure upon chemical reactions, especially in connection with the genesis of coal.

In the course of experiments on the action of water upon coal under high pressure and at high temperatures, the question arose for him whether in cracking coal or lignite it was possible to add hydrogen so as to obtain liquid hydrocarbons. He actually was the first to succeed in getting from coal, by adding hydrogen, products very much like low temperature tar or crude oil and, in the same way, light oils from heavy oils.

The first patents relating to the hydrogenation of coal Bergius obtained in the year 1913 while still working at the School of Technology, Hannover. His subsequent experiments were carried out at Goldschmidt's laboratories at Essen, later on at Mannheim-Rheinau in a plant specially built for his purpose.

The difficulties that Bergius had to struggle against resulted, as in the ammonia synthesis, largely from the combination of high temperatures and high pressure. On attempting large scale operations, however, unprecedented difficulties arose. Pulverized coal in the form of a thick paste had to be pumped through the high pressure apparatus, and pipes and vessels became stopped up, the pumps clogged, and the wear and tear was enormous. Entirely new apparatus had to be invented, and entirely new materials had to be found. Tenacious and ingenious, Bergius did his best to overcome these difficulties, and much progress in the technology of high pressure is due to his efforts.

Though his patents are fundamental the hydrogenation process took the decisive direction only when in spite of all doubts that had been uttered with respect to the poisoning character of the crude materials involved, the I. G. Farbenindustrie Aktiengesellschaft applied catalysis.

An outstanding characteristic of Bergius is his wealth of inventive ideas and his unceasing activity that impels him to keep in quest of the new.

At the convention held by the Association of German Chemists in 1928, Bergius presented the results of 14 years' labor in a new field of research: the chemical utilization of wood. Following up Willstaedter's research work on the hydrolysis of wood, he succeeded in working out

a simple technical process of converting, by means of hydrochloric acid, the indigestible (cellulose) substances of the wood into digestible carbohydrates, thus obtaining from waste wood a valuable fodder. Though the process has, as yet, no practical importance for agriculture, it is not unlikely that under changing conditions it may become a commercial proposition.

Bergius' personality is not easily gauged from a merely casual meeting. Most people who have become acquainted with him in social intercourse see in him the man of esprit and the man of the world, the generous patron of the arts and sciences. Yet, this is only one aspect of him. Behind his apparent ease and suavity there is however an extremely serious and diligent worker who tackles problems with unimpeachable logic and a rare tenacity of purpose.

It deserves to be mentioned that Bergius who has contributed much to science has, whenever possible, largely contributed also to the furtherance of scientific institutes, and the research organization he created has been maintained by him even in times of adversity and at great financial sacrifice.

That Bergius has avoided academic ties and industrial association is attributable not only to his love of freedom; he, no doubt, clearly realized that his faculties found the necessary scope only in complete independence.

Yet both Bergius and Bosch have received public recognition, universities have made them honorary doctors, prominent societies honorary members. These and many other distinctions have now been crowned by the Nobel Prize.

ALVIN MITTASCH

MANNHEIM, GERMANY

PROFESSOR OTTO WARBURG, RECIPIENT OF THE NOBEL PRIZE IN MEDICINE

PROFESSOR OTTO WARBURG who was awarded the Nobel Prize in medicine for 1931, published his first investigation of cellular respiration twenty-four years ago. Since then there has come from his laboratory a copious flow of papers on this subject, and on other processes by which energy is supplied to the cell. A first glance at the titles of his papers shows that many of them have been on fertilization, photo-synthesis, cancer, nitrate reduction by bacteria and on other apparently unrelated phenomena. Closer study reveals the fact, however, that in all these investigations Warburg's thought was directed toward investigating the energy-producing processes of the cell, and especially toward respiration. It is difficult for us to perceive how Warburg first arrived at this point of view, maintained throughout all his work, for, curiously enough, before his paper of 1908 he had spent several years in research on organic chemistry in Emil Fischer's laboratory. And yet it is not organic chemistry, but rather the physiology of Lavoisier and Pasteur that forms the background of Warburg's contributions.

The experimental methods employed by Warburg combine simplicity and elegance with imaginative daring, so that his work possesses a kind of beauty rarely achieved in chemical physiology. These qualities were developed gradually over a period of twenty years. They developed only in response to the needs created by an ever-deepening insight into the nature of the problems studied. One characteristic of Warburg's experimental procedures was present, however, from the very beginning of his investigations. His methods, by never causing a permanent injury to cells, made possible the study of normal respiration. One way of avoiding injuring the cell

PROFESSOR OTTO WARBURG

was (as many other investigators have done) to select for his experiments red blood cells or unicellular organisms, such as sea urchin eggs, yeasts, bacteria and algae. Being eager to extend his studies to the tissues of higher animals, he boldly conceived the idea of cutting thin slices of tissue, so thin that simple diffusion suffices for the transport of materials between the cells of the tissue and the fluid in which the piece of tissue is suspended. It seems scarcely credible that the respiration of a thin slice of tissue could proceed at the same rate as it does in the same tissue in its normal position in an organ. And yet direct experiments (by other investigators) have shown that the rates of respiration in the two, excised and intact tissues are the same. Previous methods of measuring the respiration of isolated tissues involved the use of rather thick pieces of tissue, in which diffusion between tissue and surrounding medium was inadequate for the needs of the cells; or of tissues which were finely minced, so that their cells were seriously injured.

Even after one has acquired a mastery of the methods of measuring the respiration of isolated cells and of excised tissues, how is the chemical mechanism of respiration within the living cell to be analyzed? Substances which are stable when exposed to oxygen outside the organism, in cells of the organism are burned by oxygen readily. There must, therefore, be catalysts in the cells which speed up oxidations. To investigate these catalysts Warburg turned to one of the old methods of physiology—to the use of poisons. In his hands this method became the most precise and powerful technique of chemical physiology. Poisons that do not injure the cell irreversibly and which have a highly specific inhibiting action can be used chemically to probe, as it were, the catalysts within the cell. The next step is to discover how the poison inactivates the respiratory catalysts. This can be learned by constructing a relatively simple oxidizing system in a test tube on which the inhibiting action of the poison can be imitated. The analogy between the systems *in vivo* and *in vitro* is then made as exact as possible, and if the nature of the catalyst inactivated *in vitro* is known, it is inferred that the same catalyst is present *in vivo*. Study of the system *in vitro* can also provide clues for a more direct investigation in the cell. The success of the inhibitor technique depends upon the use of a poison which is highly specific, which can in fact act on only one type of catalyst.

Early in his studies Warburg came to the conclusion that iron acts as an essential respiratory catalyst. This conclusion depended on the observation that on the one hand respiration can be inhibited reversibly by minute concentrations of cyanide or hydrogen sulfide, while heavy metal compounds can catalyze *in vitro* the oxidation of biological substances, but become catalytically inactive when combined with cyanide and hydrogen sulfide. The heavy metal active in the cell was supposed to be iron because iron is the heavy metal present in tissues in the highest concentration. Experiments with cyanide and hydrogen sulfide failed, however, to fix the precise nature of the heavy metal compound. At first the inhibitors used were not specific enough in their action and, furthermore, the evidence was based entirely on analogy.

Warburg's next step was the discovery that tissue respiration may be inhibited completely and reversibly by carbon monoxide. It had long been known that when small concentrations of carbon monoxide are inhaled by vertebrates, poisoning ensues. Claude Bernard in 1883 discovered that carbon monoxide acts by combining with hemoglobin and by so doing renders red blood corpuscles unfit to transport oxygen to the tissues.

Animals which do not depend on hemoglobin for this function are not influenced by low concentrations of carbon monoxide. Higher concentrations, however, of carbon monoxide were found by Warburg to inhibit the respiration of all living tissues, plant as well as animal. When carbon monoxide combines with hemoglobin it does so with the pigmented part of the molecule. This pigment is an iron-porphyrin complex. Warburg was, therefore, led to suppose that it must be an iron-porphyrin complex which exists in all respiring tissues, where it acts as a respiratory catalyst or enzyme. The evidence for this belief depended on the observation that iron-porphyrin compounds can catalyze oxidations *in vitro*, but that when these compounds are combined with carbon monoxide they are catalytically inactive. The analogy between the behavior of the iron-porphyrin catalyst in the test tube and the respiratory catalysts present in the cell is made much closer by studying the action of light on the two systems. It had already been discovered by J. S. Haldane that the combination between hemoglobin and carbon monoxide is dissociated by light. Warburg now found that by the action of light the inhibitory effects of carbon monoxide on tissue respiration is abolished. The manner in which carbon monoxide inhibits tissue respiration suggests strongly, therefore, that it is an iron-porphyrin compound which acts as a respiratory catalyst in living tissues.

At this point the method developed by Warburg becomes so much more precise that the nature of the respiratory ferment inactivated by carbon monoxide can be clearly and decisively demonstrated. The part of his procedure which yields an entirely new kind of information is spectrum analysis, for this permits the demonstration not only that the respiratory ferment has some peculiar properties also possessed by iron-porphyrin compounds but that the respiratory ferment definitely is an iron-porphyrin compound. Light of one color is more effective in influencing the carbon monoxide inhibition of respiration than light of another color. This means that the carbon monoxide compound of the respiratory ferment is a pigment which absorbs one kind of light more than another. Suitable quantitative experiments on the effectiveness of different kinds of light permit the calculation of the precise extent to which the carbon monoxide compound of the respiratory ferment absorbs different kinds of light or, in other words, the calculation of the ferment's spectrum. The spectrum found is that of an iron-porphyrin compound. No substance can have this spectrum, regardless of how it can react with carbon monoxide or any other inhibitor, unless it has an iron-porphyrin molecular structure.

When one considers that the iron-porphyrin ferment of respiration is present in one part only in a hundred million, it is remarkable that its existence has been discovered. Isolation of so minute an amount of ferment seems out of the question. And ordinary analytical methods of chemistry do not permit the identification of the nature of so small amounts of a substance even if it can be isolated. Fortunately, the actual measurement of the ferment's spectrum by the carbon monoxide inhibitor technique depends on the results of the presence of the ferment which are great, despite its small concentration. The demonstration of the iron-porphyrin nature of the respiratory ferment is all the more striking when one considers that until Warburg's investigations the chemical nature of no other intracellular enzyme present in minute amounts was known, and that extremely little is known about the normal function even of the ordinary, well-studied constituents of the cell which are present in large amounts.

Due to Warburg's researches more is

now known about the function of the iron-porphyrin ferment than about any other factors in cellular respiration. It should be remembered, however, that this ferment is only a part, though an essential part, of the respiratory system of the cell. Ordinary oxygen does not in fact react directly with the foodstuffs within the cell. It acts indirectly by combining first with the iron-porphyrin ferment, but whether oxidized iron-porphyrin ferment acts directly on the metabolites is unknown. There are probably additional intermediary ferments. It is known that the foodstuffs, or metabolites, are converted, furthermore, into readily oxidizable forms. Metabolites, as well as oxygen, require "activation." The complexity of the system probably makes possible that regulation of activity in response to the needs of the cell so characteristic of living systems.

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THE AMERICAN INSTITUTE OF PHYSICS

As the science of physics has developed and its applications have increased in importance, specialized groups have necessarily grown up. While the result has been the further progress of such special interests, something of the inherent unity of physics has been lost sight of. In a very general sense a unifying step now seems decidedly called for. There have appeared, moreover, several immediate specific problems which can only be attacked adequately with the whole support of all who are interested in physics. One of these is considered to be of the most immediate importance, and it is the pressing nature of this particular problem that has supplied the necessary driving force for the initiation of the movement which this article describes.

To meet the generally recognized need for an agency suitably constituted to undertake cooperative projects, the American Physical Society, the Optical Society of America, the Acoustical Society of America and the Society of Rheology have formed the American Institute of Physics. This new organization is controlled by the four societies and certain specific tasks have been outlined for its first efforts. It does not have individual memberships at the present time, and its constitution is still in process of development. On the other hand, its first tasks are definitely set.

The four societies publish seven journals all more or less technical in character. They are the *Physical Review*, *Review of Modern Physics*, *Physics*, the *Journal of the Optical Society*, the *Review of Scientific Instruments*, the *Journal of the Acoustical Society*, and the *Journal of Rheology*. With perhaps one exception these journals are projects which the societies find increasingly difficult to support, yet they are vitally necessary publications. This situation was brought to the attention of The Chemical Foundation, whose financial assistance in publications of a scientific character is well known. In conference it was recommended that a cooperative organization, representative, so far as possible, of all physics, should be formed at once, and the material help of The Chemical Foundation in such a project was promised.

A cooperative committee of the four societies was formed, and this has now become the Governing Board of the American Institute of Physics. It consists of three representatives chosen by each society, making a board of twelve in all. The initial personnel is as follows: Physical Society: Karl T. Compton, Chairman of the Board; George B.

RECIPIENTS OF ENGINEERING HONORS

PROFESSOR M. I. PUPIN, OF COLUMBIA UNIVERSITY, WHO RECENTLY RECEIVED THE JOHN FRITZ GOLD MEDAL AWARDED JOINTLY BY THE FOUR NATIONAL ENGINEERING SOCIETIES, AND DR. E. W. RICE, JR., OF THE GENERAL ELECTRIC COMPANY, WHO WAS GIVEN THE EDISON MEDAL BY THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

Pegram, Secretary; John T. Tate. Optical Society: Paul D. Foote; Loyd A. Jones; F. K. Richtmyer. Acoustical Society: H. D. Arnold; Harvey Fletcher; F. A. Saunders. Society of Rheology: E. C. Bingham; Wheeler P. Davey; A. Stuart Hunter.

It is at present contemplated that each member shall serve three years, a new representative to be elected to replace one retiring each year by each society.

At a meeting held at Schenectady in September the board appointed the writer to act as Director of the new institute. Dr. John T. Tate, professor of physics, University of Minnesota, who is editor of the journals of the Physical Society, was appointed adviser on publications.

The office of the American Institute of Physics was opened in October at 654 Madison Avenue, New York, N. Y., rooms in the office of The Chemical Foundation being made available for this purpose. Work commenced at once under three headings, namely, publications, organization and public relations.

Publications

The first task is to study the financial problem, gathering data concerning subscriptions, number of pages, printing costs, etc. The second is to evolve a plan of reorganization which will ensure the services of the publications to the members according to the same high standards as at present and at the same time effect pronounced economies. It is too early to say in detail how this may be done. It can be said, however, that there is no thought of taking the editorial direction of the journals out of the hands of the societies. It is recognized that an editor appointed by and acting for each society must have complete authority to decide what material is to be printed.

There is, on the other hand, no reason why each society should burden itself with the business of subscriptions, advertising, printing and mailing. To do all this similar business for the seven journals in one office would be to adopt recognized economic business principles. There would be a saving of time and money and probably an increase in efficiency. The institute would become a publishing agent for the societies. It would have the strength of the combined circulations of the seven journals in negotiations with printers and advertisers, obviously to the advantage of the journals. The institute will work out the details of a plan embodying these features and submit the plan to the societies.

Organization

The committee which organized the institute realized that other groups beside the four societies they represented were interested in the movement and should be associated with it. The new American Association of Physics Teachers is one of these, and it is hoped that when this association is in full operation it will likewise participate in the responsibilities and services of the institute. There are other national and local groups, some very active, of persons interested in physics and its applied branches. It is regarded as very desirable to enlist the interest of these groups in the institute and to make the institute of service to them. A large number of suggestions in this direction have already been made and these are being carefully analyzed as to desirability and feasibility. The problem is a large one that has been growing up for years and naturally it can not be solved in a few months. A great deal of caution must be observed, moreover, in initiating new ventures at a time when financial support is hard to find. It often turns out also that a demand for a particular project does not have behind it the support of the numbers that its vehemence indicates. Thus any service—such as a publication—which may be contemplated

must be limited to such features as are fairly certain to attract a wide approval. The officers of the institute are conferring with local groups with the object of isolating such features.

Public Relations

In the progressive world of the present day, science has become the center of an increasingly broad and enlightened public interest. In the words of one of the editors of *The New York Times* "Science is news—front page news!" It is recognized that to-day's discoveries in the fundamental sciences may have more effect on the future of the human race than the rise and fall of governments or of economic institutions. It becomes the duty of the scientist who lives as an integral part of to-day's world to keep the public informed accurately and fully of those developments which bid fair immediately or indirectly to alter the general environment.

It is also well known that newspapers and popular periodicals are a tremendous medium for education. The scientific world should use this medium for the broader dissemination of knowledge.

With all the public appreciation of fundamental science, however, there is an astonishing lack of realization that in inanimate nature the fundamental science is physics. Chemistry is everywhere known for what it is. In its applications, physics, on the other hand, is not known as physics. It is known as engineering. Many laymen do not know that radio, refrigeration, sound motion pictures, etc., are physics. Hence the recognition which these innovations should have brought to physics has been lost. The result has been that many grants and bequests for research which might have come to physics have been used in less fundamental, even though still worthy fields. Also a man calling himself a physicist has been something not understood—perhaps "a kind of chemist"—and by virtue of the uncertainty has found that his profession did not provide for him an economic security appropriate to his ability.

The American Institute of Physics is undertaking a study of the relation between science and the press. It proposes to prepare for the papers suitable accounts of the research activities of the members of the societies and the proceedings at the meetings. It has already been found that the science reporters of the papers will cooperate whole-heartedly in such a program. It may be confidently expected that the ultimate result will be an improvement in the status of the physicist.

Conclusion

The very multitude of tasks already presented or proposed to the institute is a convincing evidence that here is a development brought about by the pressure of real forces and that its existence is a real necessity. It is not a result of misguided ambition to start something new, and it is free from any element of artificiality. In the manner that a research tool, like the vacuum tube, created for a specific scientific purpose, is likely to open up new fields of research, the institute may go far in the future development of physics. Certainly further applications of this cooperative research tool will be found. It depends, like any other human activity, upon the continued active and loyal support of those who want it. In the meantime its further development should be steady and well founded rather than rapid.

Henry A. Barton